GREATER TORONTO AREA
URBAN STRUCTURE CONCEPTS STUDY

BACKGROUND REPORT NO. 3
TRANSPORTATION SYSTEMS

Prepared for
The Greater Toronto Coordinating Committee

IBI GROUP
in association with
RICHARD M. SOBERMAN
LAVALIN ENGINEERS INC.

JUNE, 1990

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91-01165/

June 12, 1990

Mr. E. M. Fleming
Chairman
Greater Toronto Coordinating Committee
5 Park Home Avenue
Suite 210
North York, Ontario
M2N 6L4

Dear Mr. Fleming:

Background Paper No. 3: Transportation Systems

This is the third in a series of background reports for the Greater Toronto Area Urban Structure Concepts Study. The background reports in the series are as follows:

1. Description of Urban Structure Concepts;
2. Minimal Growth Option;
3. Transportation Systems;
4. Water, Sewers and Solid Waste;
5. Greening/Environment;
6. Human Services;
7. Comparison of Urban Structure Concepts;
8. Public Attitudes Survey (to follow in Fall, 1990).

The overall study results are presented in a separate report titled Summary Report: Greater Toronto Area Urban Structure Concepts Study.

This background report describes the transportation system concept which was developed for each of the three urban structure concepts and the manner in which the conceptual systems were analyzed in terms of transportation demand levels and required capacity/sizing to provide an equivalent level of transportation service for each of the three urban structure concepts. The report goes on to describe the cost estimating methodology and results in terms of capital and operating costs for the three system concepts. Findings are also presented regarding energy consumption and atmospheric emissions from transportation, and the implications of specialty transportation requirements, including school busing and transit services for handicapped persons.

240 Richmond Street West, 5th Floor, Toronto, Ontario M5V 1W1 (416) 596-1930, FAX (416) 596-0644
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Transportation costs are presented both in absolute terms and in relative terms to identify differences among the three urban structure concepts. The concepts are also compared in terms of other criteria describing the efficiency and effectiveness of such services.

This study breaks new ground by drawing together demand, supply, cost and effectiveness findings for three quite different future urban forms for the entire GTA including both "hard" and "soft" infrastructure. There is, therefore, little precedent against which to assess the results, some of which are perhaps unexpected or at least thought-provoking. The results are therefore preliminary, for discussion. If, as the findings are scrutinized and the comparison ratings are discussed, a consensus emerges regarding a preferred future urban structure for the GTA and/or a process for moving purposefully in that direction, the study will have served its purpose.

The opinions offered herein are those of the consultant and reflect to the extent possible comments received from the Urban Structure Subcommittee established for this study. They do not necessarily reflect the views of the Greater Toronto Coordinating Committee or the governments represented on the Committee.

We trust that the information and opinions offered will be helpful in the context of the study and subsequent planning activities and decisions.

Yours sincerely,

IBI GROUP

Neal A. Irwin
Managing Director

Lee S. Sims
Director

NAI:mr

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Greater Toronto Area Urban Structure Concepts Study: Background Report No. 3: Transportation Systems: Executive Summary

PURPOSE OF REPORT

The purpose of this report is to compare the transportation implications of the three urban structure concepts, concentrating on the differences among the three concepts in order to provide input to the discussion of the advantages and disadvantages of each concept.

DEVELOPMENT OF TRANSPORTATION CONCEPTS

To this end, conceptual transportation plans were developed for each of the three urban structure concepts. The transportation demands for each were examined and networks developed based upon the following themes:

- **Concept 1: Spread**. The distribution of land uses in this concept would encourage the growth of radial trips from the regions into Metropolitan Toronto. There would also be substantial increases in trips within and between the four suburban regions. Therefore, this transportation network concept emphasized the completion of the grid of freeways in the region as well as the further development of the GO Transit commuter rail network. The rapid transit network was assumed to include projects already announced with some minor extensions;

- **Concept 2: Central**. As much of the population and employment increase is concentrated within Metropolitan Toronto in this concept, major extensions of the rapid transit network in Metro and in adjacent parts of the regions were included. Only freeway extensions already announced were included in the freeway network. The commuter rail network would be improved but no new lines would be added; full service would be concentrated mainly in the central, built-up areas;

- **Concept 3: Nodal**. In the transportation concept for this urban structure, a less extensive freeway network was postulated than in Concept 1, the GO Transit network was extended as in Concept 1 and a moderate extension of the rapid transit system was assumed, with emphasis on rail rapid transit and express bus services linking the various nodes.

ANALYSIS OF CONCEPTS

A major tool used in this analysis was the development of a computerized travel demand model to examine the differential demands associated with the three concepts.

Travel Demand Patterns

The differences in travel demand among the three concepts are estimated to be as follows, expressed in thousands of person trips in the 6:00 a.m. to 9:00 a.m. peak period:

	Concept 1	Concept 2	Concept 3
Trips within Metro	939	1,524	1,076
Trips to Metro from Regions	492	298	417
Trips from Metro to Regions	205	246	233
Trips within Regions	1,067	696	998
Trips between Regions	149	88	128
	2,852	2,852	2,852

Modal Split and Trip Length

The major attributes of the trips estimated for 2021 were as follows:

	Concept 1	Concept 2	Concept 3
Transit Modal Split (peak period)	26%	35%	29%
Average Trip Length (km)	15.0	13.2	14.3

Capital Costs

Based upon the analysis of travel demand, the three networks were sized and costed. The costs are based on a conceptual level of detail. Expected expenditures between 1990 and 2021 were estimated as follows in billions of 1990 dollars:

	Concept 1	Concept 2	Concept 3
Public Transit	$ 7.2	$14.4	$11.6
Major Roads	19.9	13.2	17.0
Total	$27.1	$27.6	$28.76

Operating Costs

Although not explicitly asked for in the Terms of Reference for this study, a comparison was made of the operating costs of the various modes as it was expected that there could be major differences among the three concepts. The estimated 2021 total annual operating costs in billions of 1990 dollars for the three concepts were estimated as follows:

	Concept 1	Concept 2	Concept 3
Public Transit	$ 1.1	$ 1.4	$ 1.3
Road - Operations	0.2	0.2	0.2
- Users	10.1	8.0	9.2
School Bus	0.3	0.2	0.2
Handicapped	0.2	0.1	0.2
Total	$12.0	$ 9.9	$11.1

COMPARISON OF CONCEPTS

The three urban structure concepts were then compared on the basis of two transportation factors and several measures defined within each of the factors. The factors and measures are:

- **Factor 3.1**: Choice of modes and service levels;
  - high transit accessibility and service level;
  - high road accessibility and service level;
  - high effectiveness of intercity connections;
  - high population accessibility to rural areas.
- **Factor 3.2**: Transportation efficiency and costs.
  - low average travel times, distances and costs;
  - high proportion of each region's work trips to remain in the region;
  - high transit efficiency and cost recovery;
  - reduced road traffic congestion growth;
  - reduced requirements for school busing;
  - better opportunity and less cost to provide transit for handicapped persons;
  - low transportation capital costs;
  - low transportation operating costs.

GTA Urban Structure Concepts Study: Background Report No. 3: Transportation Systems

1. INTRODUCTION

1.1 BACKGROUND

Three urban structure concepts have been developed for the Greater Toronto Area (GTA). They represent three, quite distinctive ways of allocating growth between today and the year 2021. The three concepts were developed following these guidelines:

1. A status quo concept, representing a continuation of existing trends, characterized by substantial population growth in the suburban regions at relatively low density, with continuing concentration of office development downtown and in various subcentres in Metro and the four adjacent regions (designated as **Concept 1, Spread**);

2. A concept in which substantial additional population growth/intensification would occur within Metro Toronto, and other "mature" urbanized areas adjacent to Metro along with further intensification of employment activities such that the rate of urbanization occurring beyond Metro boundaries would be significantly reduced (referred to as **Concept 2, Central**); and

3. An intermediate concept in which residential and employment growth would occur primarily in and around various existing communities in a compact form, resulting in reduced consumption of undeveloped land relative to Concept 1 (referred to as **Concept 3, Nodal**).

1.2 PURPOSE AND SCOPE

The purpose of this background report is to describe the transportation implications of these three urban structure concepts.

All forms of transportation were investigated including school busing, handicapped transportation, and inter-city transportation but the emphasis of the analysis was on the public transit and roads systems within the GTA, as these represent the higher cost portions of the transportation systems, and the areas for which differences in urban structure may be expected to have the greatest impacts.

The analysis methodology was developed to respond to the section of the Terms of Reference for the project which states:

"Capital cost estimates will be required for all facilities needed, in addition to those that exist and are in use at the end of 1989. This cost is to represent the gross cost of all facilities except those which have been customarily the responsibility of the private sector. Gross costs of facilities if any to be funded by the Federal Government are to be separately identified. The estimates are to be expressed in terms of constant 1990 dollars for each discipline with major items separately identified and are to include an appropriate contingency which is to be stated."

1.3 EXISTING TRANSPORTATION SYSTEMS

The GTA is made up of the Municipality of Metropolitan Toronto and the Regional Municipalities of Halton, Peel, York and Durham. Within the five regions, there are a total of thirty area municipalities.

The road system is organized in three levels:

- a provincial network made up of major freeways and inter-city highways built and operated by the Ministry of Transportation of Ontario (MTO);
- systems of major arterial roads owned and operated by each of the five regions including some urban expressways under the jurisdiction of Metropolitan Toronto;
- roads owned and operated by the area municipalities which include arterial roads, collectors and local roads.

There are also 16 public transit systems operating in the GTA:

- the GO Transit system which is provincially funded and administered by a board made up of the chairs of the various regions. GO Transit operates inter-regional rail and bus services;
- the Toronto Transit Commission which operates public transit services on behalf of Metropolitan Toronto within Metro with some extensions into adjacent municipalities;
- a total of 14 transit systems operated by area municipalities in other regions.

Inter-city transportation services are provided in the following manner:

- **Rail.** Freight services are operated by Canadian National and Canadian Pacific. Passenger services are operated by a federal crown corporation, VIA Rail Canada Inc.;

- **Air.** Transport Canada operates the major airport in the region, Lester B. Pearson International Airport. The Toronto Island Airport is operated by the Toronto Harbour Commissioners. There are a number of smaller privately operated airports. Air services are operated by a variety of Canadian and foreign carriers;

- **Ports.** There are two ports in the GTA administered by agencies established by the federal government: the Port of Toronto through the Toronto Harbour Commissioners and the Port of Oshawa through the Oshawa Harbour Commission. There are also a number of docks and port facilities operated by a wide variety of private agencies;

- **Intercity bus.** Inter-city bus services are operated by public and private sector carriers including Gray Coach Lines which is a subsidiary of the Toronto Transit Commission and private carriers such as Voyageur, Greyhound and others.

1.4 BASIC METHODOLOGY OF THE STUDY

To analyze the road and public transit service requirements of the region, a computerized transportation demand model was applied for each of the three land use concepts. Transportation networks were developed and "sized" based on an analysis of the expected demand. Based upon the networks and the analysis of demand, capital and operating costs were derived.

Other aspects of transportation such as intercity transportation, and school busing were examined in a more qualitative manner, where relevant using extrapolations of existing expenditures.

2. DEVELOPMENT OF TRANSPORTATION CONCEPTS

Transportation is a derived service; it is not consumed for itself but in the course of other activities. Therefore any analysis of transportation need must be based on an appreciation of the distribution of these other activities.

2.1 THE URBAN STRUCTURE CONCEPTS

The basis for developing the three urban structure concepts is described in more detail in Background Report No. 1: Description of Urban Structure Concepts.

Exhibit 1 shows the actual distribution of population and employment by region in the base year (1986) and the postulated distribution for each of the future years (2011 and 2021) for Concepts 1, 2 and 3. Also shown in each instance are the ratio of total employment to residential population in each region, referred to in this presentation as the activity rate, and estimates of the urbanized area and gross urban density for each concept.

As indicated in Exhibit 1, the resident population in the GTA was about 3.7 million in 1986. Based on the GTCC projections, the resident population is expected to rise to about 6 million people by the year 2021, an increase of some 2.3 million people over the 35 year period between 1986 and 2021. Similarly, total employment in the GTA is projected to rise from about 2 million jobs in 1986 to 3.4 million jobs by the year 2021, an increase of some 1.4 million jobs over the 35 year period.

Population and employment areas for Concepts 1, 2 and 3 are illustrated in Exhibits 2, 3 and 4 respectively.

2.2 EXPECTED TRENDS IN TRANSPORTATION DEMAND

As described, the three land use concepts are quite distinct and can be expected to have very different implications in terms of transportation demand.

Based upon expected population and employment growth in the GTA and using a simplified gravity model, the growth in home to work linkages from 1986 to 2021 was estimated. A summary of these results is shown on Exhibit 5 with 2021 percentage increases over 1986 census data shown in brackets. The units are 24 hour home to work linkages with the overall totals normalized to the total employment forecast for the GTA.

These estimates show the potential variation of the linkages with the balance of population and employment in each region. The main points are:

EXHIBIT 1

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GTA Urban Structure Concepts: Overview of Population and Employment Distributions by Region

	DURHAM		HALTON		METRO		PEEL		YORK		GTA TOTAL	
BASE YEAR (1986)												
Resident Population, P (000's)	326		271		2193		592		351		3733	
Total Employment, E (000's)	137		119		1349		304		170		2079	
Activity Rate (E/P)	0.420		0.439		0.615		0.514		0.484		0.557	
Urbanized Area (000's of acres)	49.2		45.4		152.9		74.1		54.8		376.4	
Gross Density ((P+E)/Urbanized Area)	9.4		8.6		23.2		12.1		9.5		15.4	
	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021	2011	2021
CONCEPT 1: Spread												
Resident Population, P (000's)	673	794	497	583	2358	2428	1060	1198	851	1007	5438	6020
Total Employment, E (000's)	280	309	244	271	1698	1724	583	631	458	505	3268	3440
Activity Rate (E/P)	0.416	0.389	0.491	0.457	0.715	0.710	0.550	0.527	0.538	0.501	0.599	0.571
Urbanized Area (000's of acres)	97.3	99.3	74.3	84.7	152.9	152.9	119.0	129.3	116.5	133.5	580.0	599.7
Gross Density ((P+E)/Urbanized Area)	10.9	11.1	10.0	10.2	26.4	27.2	13.9	14.1	11.2	11.3	16.8	16.8
CONCEPT 2: Central												
Resident Population, P (000's)	455	475	382	378	3310	3600	784	826	617	649	5438	6020
Total Employment, E (000's)	253	263	203	211	2046	2183	485	479	293	304	3268	3440
Activity Rate (E/P)	0.557	0.554	0.530	0.560	0.618	0.574	0.585	0.578	0.586	0.584	0.599	0.571
Urbanized Area (000's of acres)	98.4	70.8	59.6	61.7	152.9	152.9	96.5	98.3	77.4	80.1	483.8	483.8
Gross Density ((P+E)/Urbanized Area)	10.4	10.4	9.5	9.5	35.0	39.1	13.2	13.3	10.5	10.5	19.2	20.4
CONCEPT 3: Nodal												
Resident Population, P (000's)	595	681	464	545	2626	2800	1060	1180	703	804	5438	6020
Total Employment, E (000's)	298	312	240	266	1748	1794	600	651	383	417	3268	3440
Activity Rate (E/P)	0.484	0.458	0.517	0.488	0.666	0.641	0.571	0.547	0.545	0.519	0.599	0.571
Urbanized Area (000's of acres)	77.4	84.7	63.5	69.4	152.9	152.9	109.9	118.4	88.0	98.4	491.7	521.8
Gross Density ((P+E)/Urbanized Area)	11.4	11.7	11.1	11.7	28.6	30.0	15.0	15.5	12.3	12.7	17.7	18.1

Note: Concept 1 is the GTCC "Base Case" Projection.

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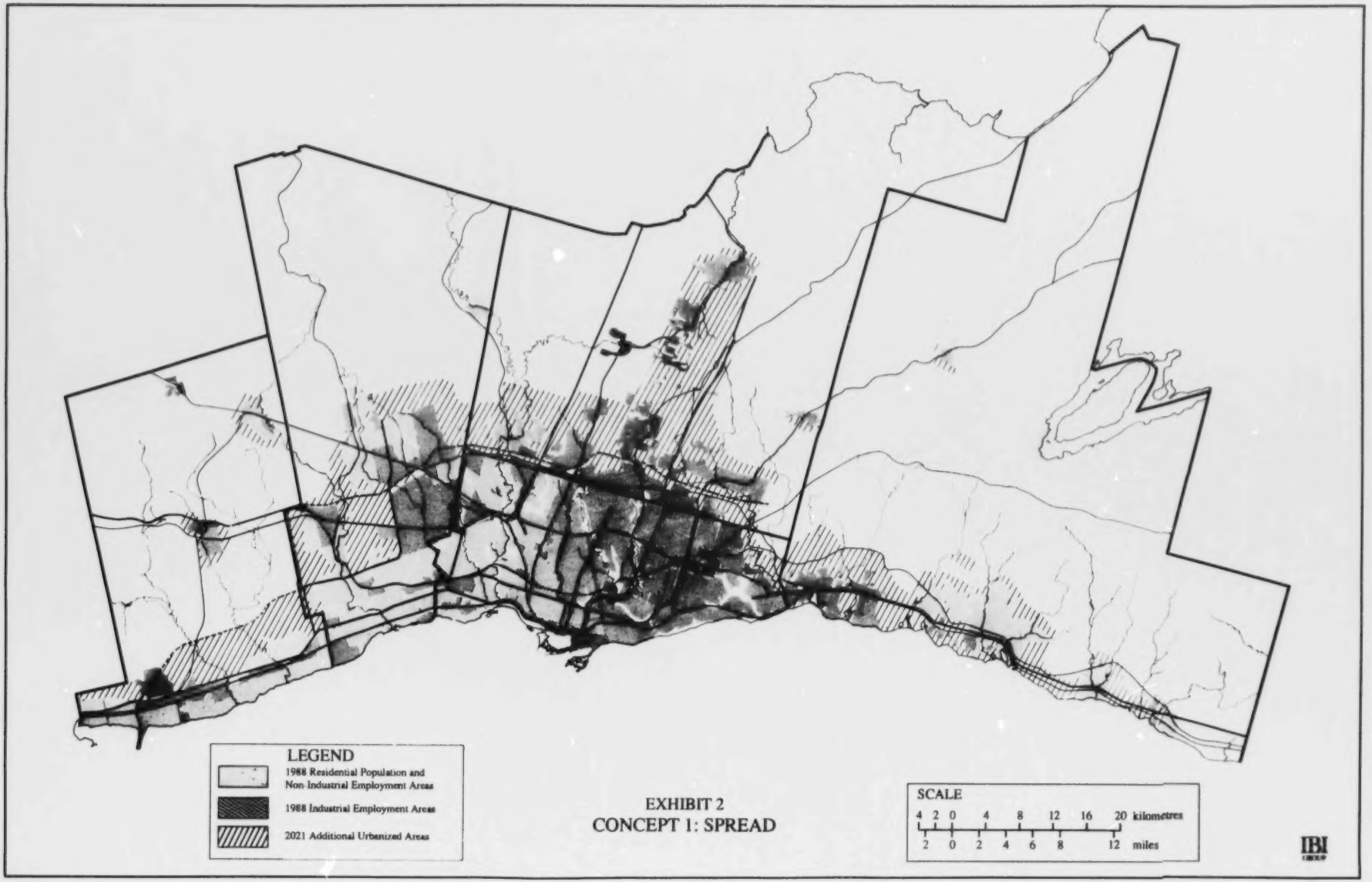
LEGEND
1988 Residential Population and Non-Industrial Employment Areas
1988 Industrial Employment Areas
2021 Additional Urbanized Areas
SCALE
4 2 0 4 8 12 16 20 kilometres
2 0 2 4 6 8 12 miles
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EXHIBIT 2
CONCEPT 1: SPREAD

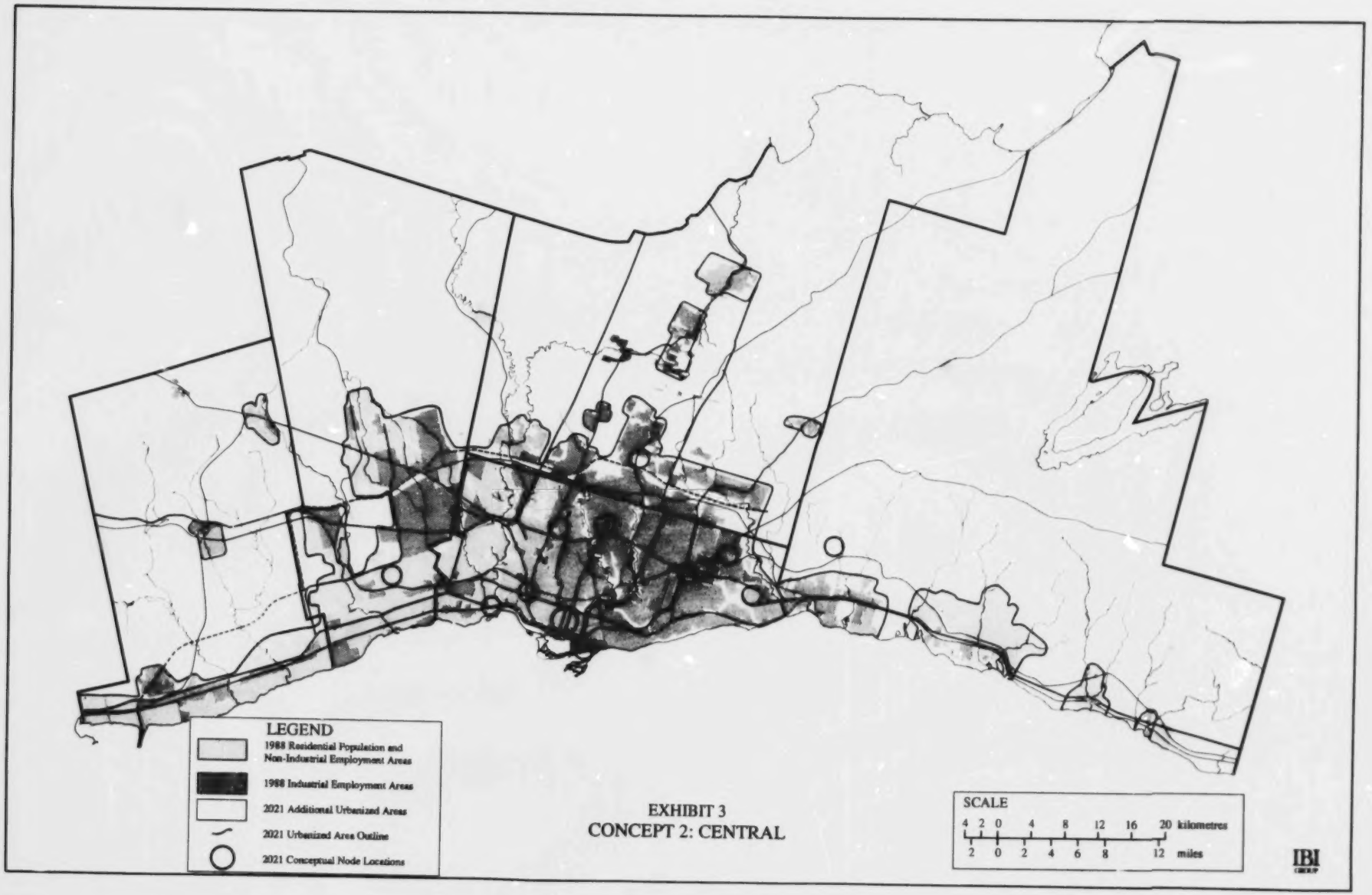
LEGEND
1988 Residential Population and Non-Industrial Employment Areas
1988 Industrial Employment Areas
2021 Additional Urbanized Areas
2021 Urbanized Area Outline
2021 Conceptual Node Locations
SCALE
4 2 0 4 8 12 16 20 kilometres
2 0 2 4 6 8 12 miles
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EXHIBIT 3
CONCEPT 2: CENTRAL

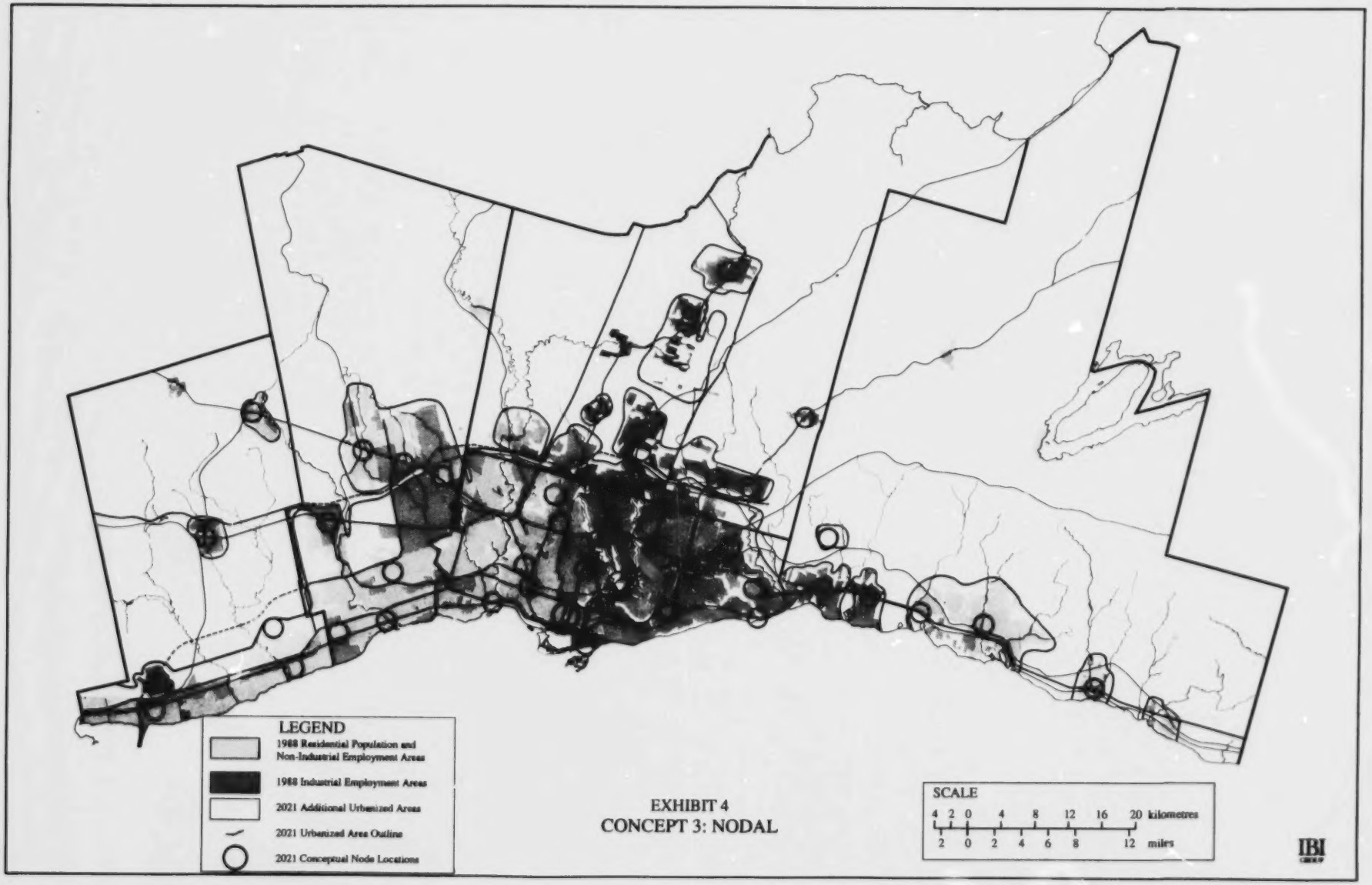
LEGEND
1988 Residential Population and Non-Industrial Employment Areas
1988 Industrial Employment Areas
2021 Additional Urbanized Areas
2021 Urbanized Area Outline
2021 Conceptual Node Locations
SCALE
4 2 0 4 8 12 16 20 kilometres
2 0 2 4 6 8 12 miles
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EXHIBIT 4
CONCEPT 3: NODAL

EXHIBIT 5

HOME TO WORK LINKAGES

(Thousands of home-work pairs)

	1986	2021 Concept 1	2021 Concept 2	2021 Concept 3
Trips within Metro	1,052	1,118 (6%)	1,810 (72%)	1,289 (23%)
Trips to Metro from Regions	297	606 (104%)	373 (26%)	505 (70%)
Trips from Metro to Regions	169	269 (59%)	361 (114%)	311 (84%)
Trips within Regions	442	1,137 (157%)	715 (62%)	1,057 (139%)
Trips between Regions	119	309 (160%)	180 (51%)	276 (132%)
	2,079	3,440 (65%)	3,440 (65%)	3,440 (65%)

Legend: xxxx = Thousands of home-work trip linkages
(x%) = Percent growth from 1986

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- Concept 1 would encourage continuing strong growth of radial trips from the regions into Toronto and would also have very substantial increases in trips within and among the four suburban regions;

- Concept 2 would have the greatest growth in trips within Metro and in reverse commuting from Metro to the regions but the smallest growth in trips from the regions to Metro;

- generally the Concept 3 demand pattern would be intermediate between those of Concepts 1 and 2. Because Concept 3 structures the new expected development into relatively compact nodes, there would be increased use of public transit relative to Concept 1, while Concept 2 would have the highest transit use of the three concepts because of the greater population density;

- there would be a large growth in trips from Metro to the regions, within the regions and among the regions in all three concepts, particularly in Concepts 1 and 2. This implies that, for all three concepts, efforts must be made to promote public transit use to workplaces in the suburbs.

2.3 THE TRANSPORTATION CONCEPTS

In the context of these demand projections, transportation network concepts were developed based upon the following themes:

- for Concept 1, increases in the radial transit links from the regions to Metro and improvements in the grid of major roads to provide access within and among the regions;

- for Concept 2, development of a more concentrated network of rapid transit services within Metro with relatively few major road investments;

- for Concept 3, a combination of the above characteristics, taking advantage of the nodal nature of the land use in Concept 3 to develop stronger transit linkages.

All three transportation networks include the elements announced by the Minister of Transportation on April 5, 1990, the "Let's Move" announcement. They do not, however, include some additional commuter rail extensions beyond the GTA announced by the Treasurer in May.

The networks developed are shown on Exhibits 6 through 14.

Concept 1: Spread

With this concept there is an increase in low density development in all directions from the central part of Toronto. Employment in the regions outside of Metro is dispersed. In addition, Metropolitan Toronto has a much higher surplus of jobs over employed labour force than in the other two concepts. Present population and labour force within Metro would increase very little over 1986 levels. To meet this challenge, the transportation network tested included the following elements:

- an extension of the GTA grid of major roads at an approximate 8 to 12 kilometre spacing. This would involve the full completion of Highways 403 and 407 (to Highway 115 in the east) and the development of a new east-west freeway further north as well as the appropriate extensions of existing north-south freeways and the addition of new freeway connections in Durham. In addition, an extension of Black Creek Drive south would be part of the concept to provide an increase in radial road capacity;

- considerable improvements to the GO Transit commuter rail system with full service being offered on most of the existing lines and new services being developed in the northwest and northeast quadrants of the city. Some services on the Milton, Georgetown and Richmond Hill lines would be diverted to serve the CP North Toronto Subdivision to connect with the Spadina and Yonge subway lines in midtown Metro, in order to provide more flexibility to users of the GO rail network;

- the rapid transit system would be expanded in line with the Minister of Transportation's announcement on April 5, 1990. This includes the Sheppard line (from Yonge to Scarborough City Centre) and the Eglinton West line within Metropolitan Toronto and the Mississauga/403 corridor (to the west limit of Mississauga). In addition, the concept includes a north-south line in Mississauga and an east-west line along the Highway 407 corridor.

Concept 2: Central

With this concept a very high proportion of the growth in population and employment would be concentrated within Metropolitan Toronto and in adjacent parts of the adjoining Regions. To meet the transportation needs of this land use pattern the transportation network tested included the following elements:

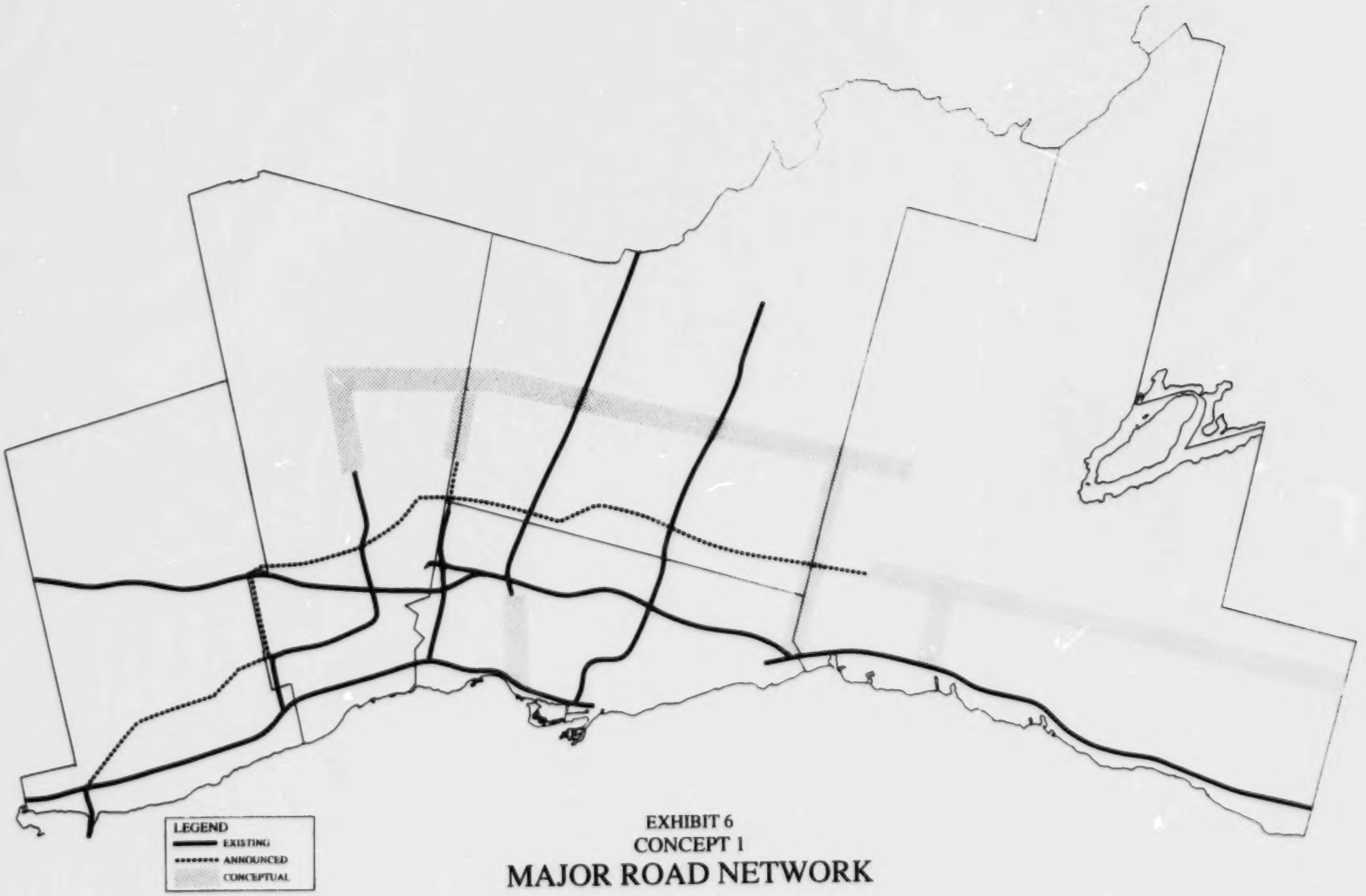

EXHIBIT 6
CONCEPT 1
MAJOR ROAD NETWORK

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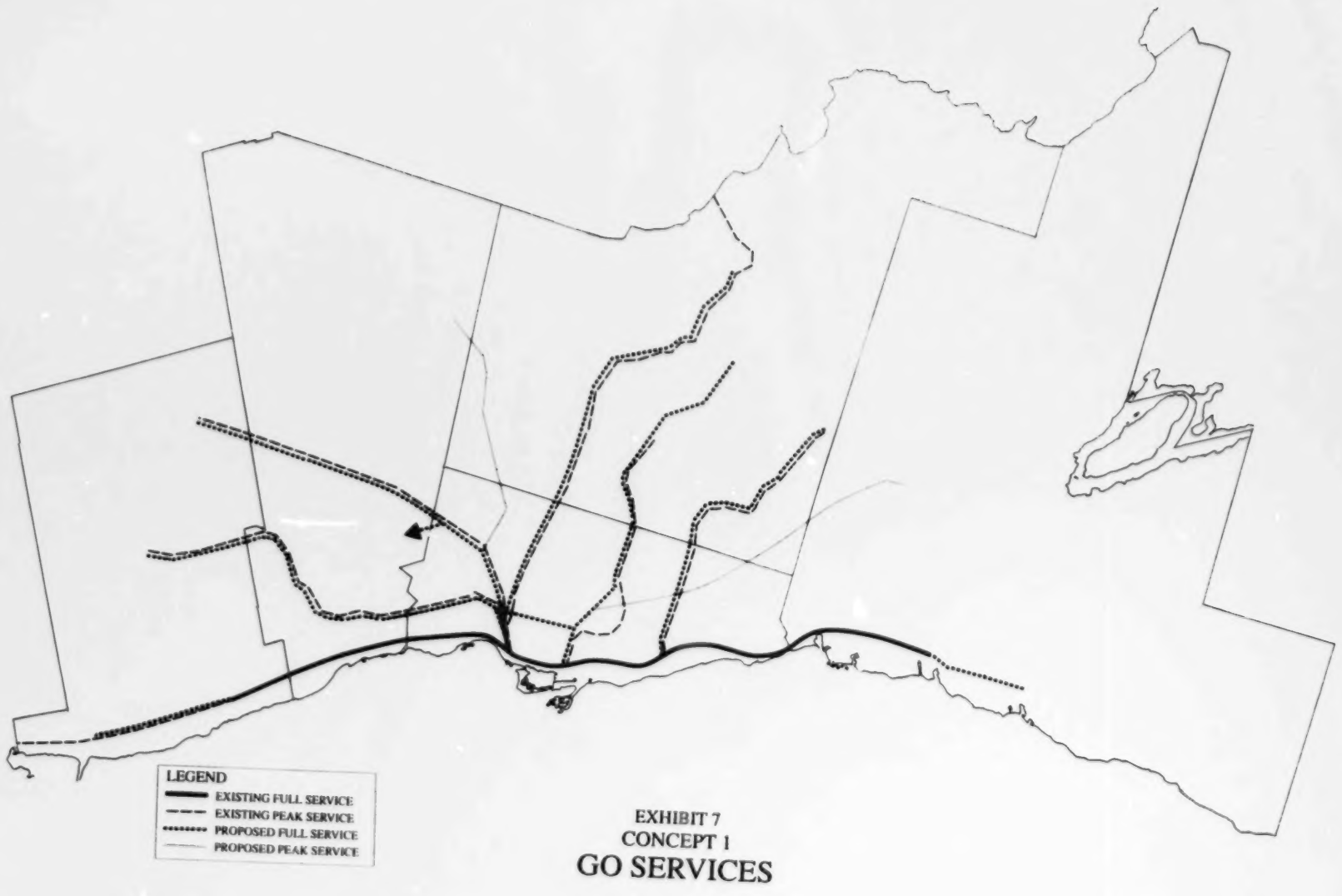

EXHIBIT 7
CONCEPT 1
GO SERVICES

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EXHIBIT 8
CONCEPT 1
RAPID TRANSIT

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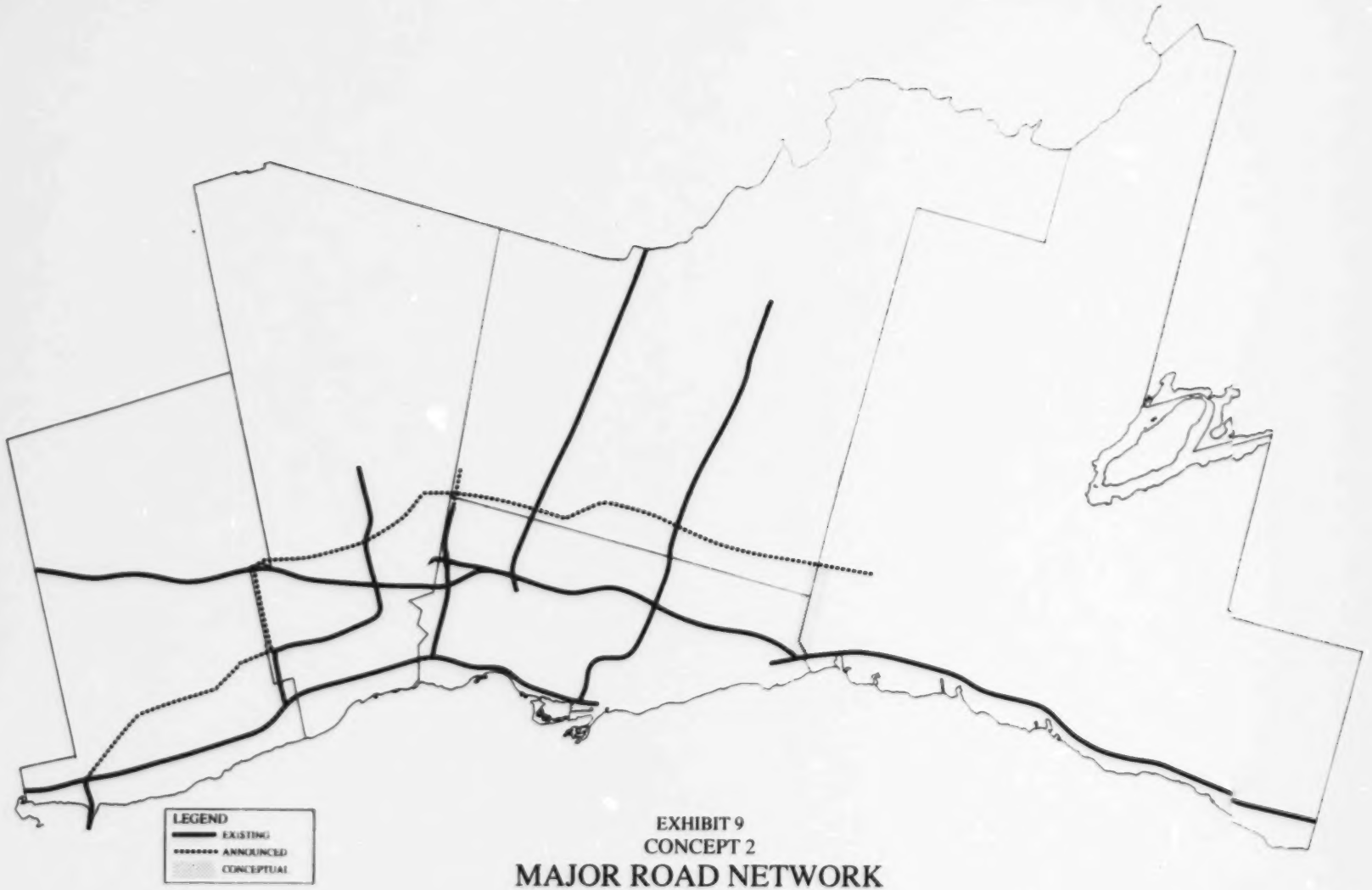

EXHIBIT 9
CONCEPT 2
MAJOR ROAD NETWORK

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EXHIBIT 10
CONCEPT 2
GO SERVICES

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EXHIBIT 11
CONCEPT 2
RAPID TRANSIT

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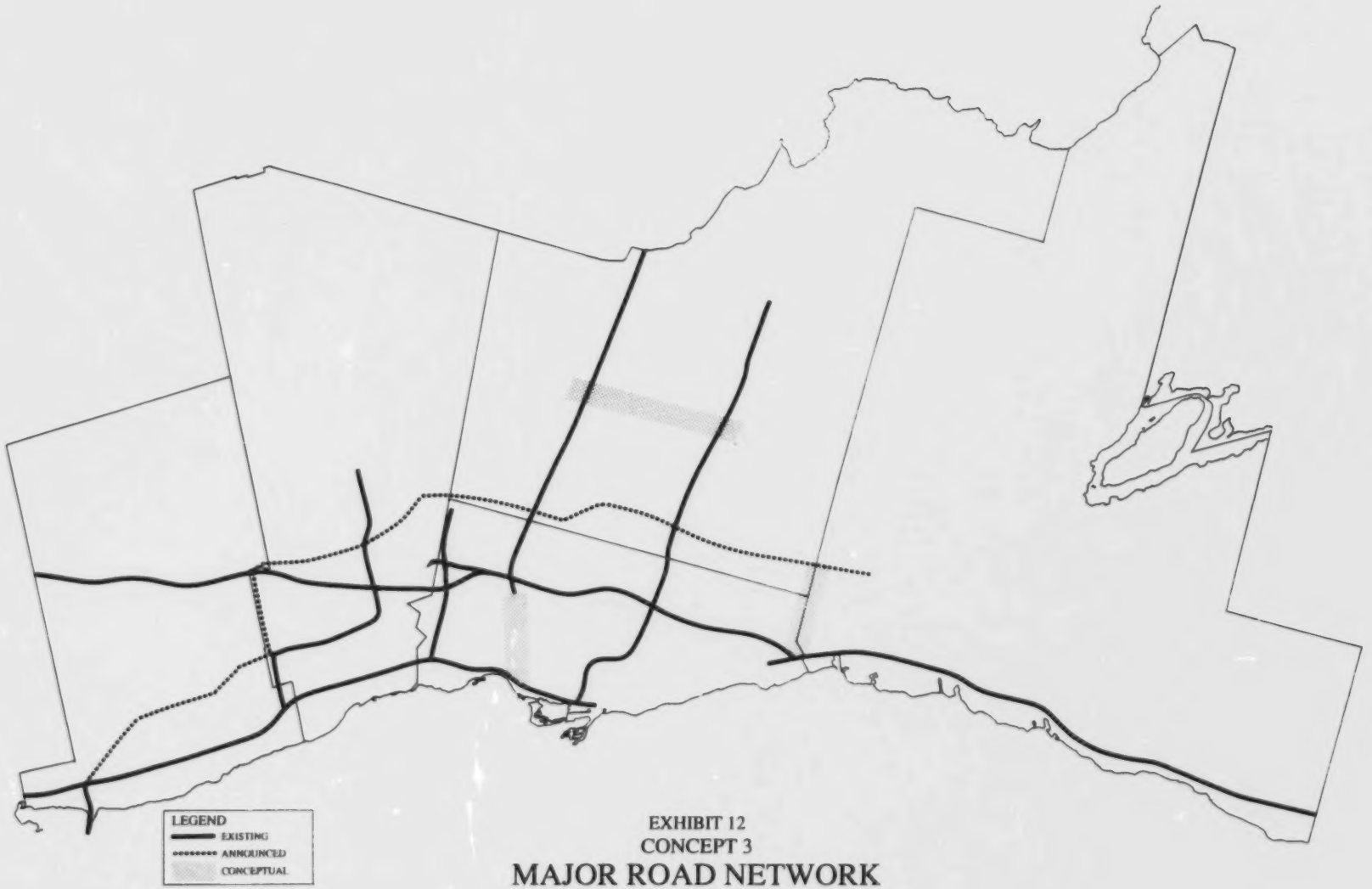

EXHIBIT 12
CONCEPT 3
MAJOR ROAD NETWORK

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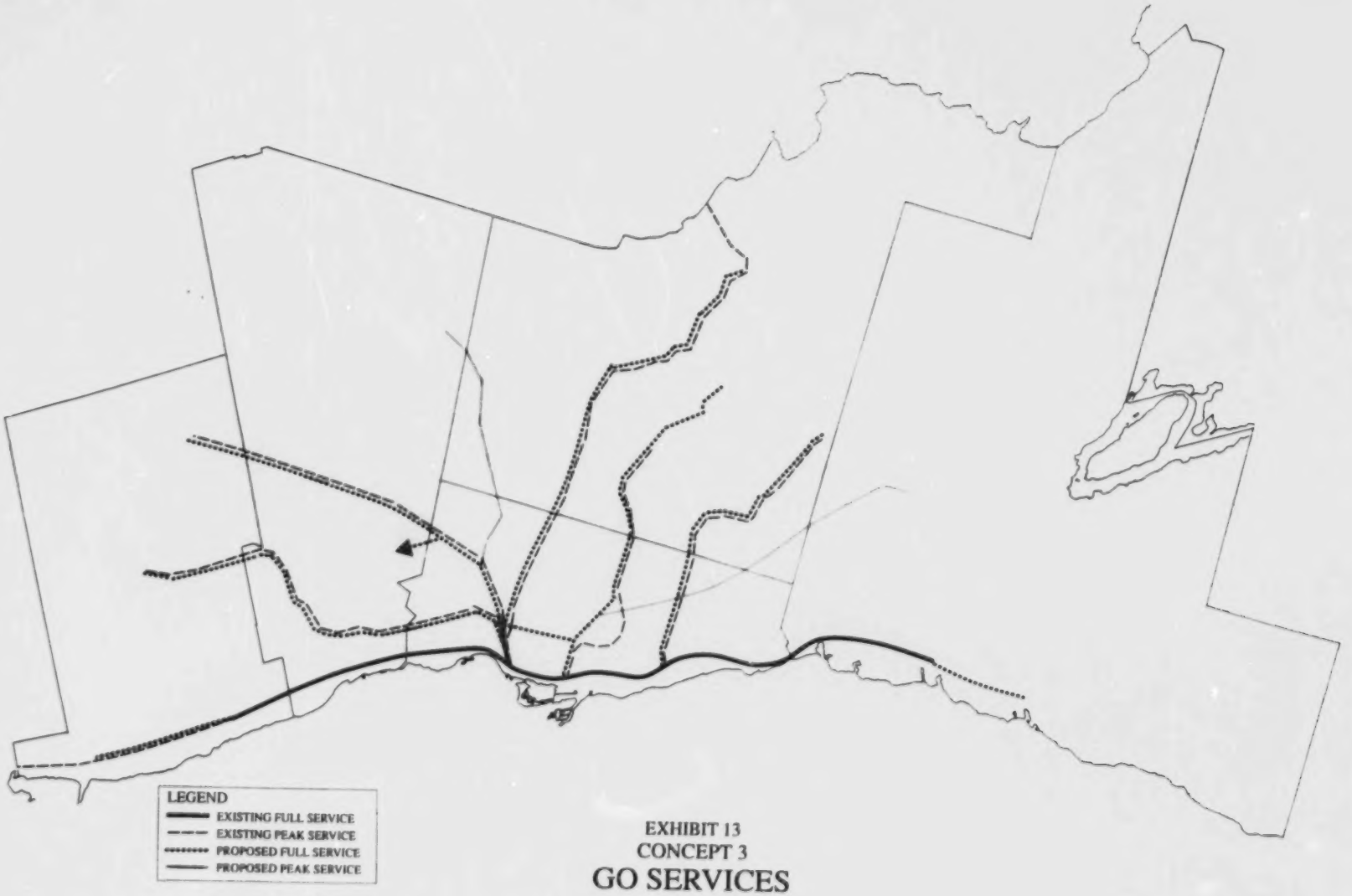

EXHIBIT 13
CONCEPT 3
GO SERVICES

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EXHIBIT 14
CONCEPT 3
RAPID TRANSIT

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- the additions to the major road system would consist mainly of the major freeway projects already announced. These include the completion of Highway 403 and the construction of Highway 407 (extended into the North Pickering area of Durham). A freeway connection between Highways 407 and 401 in the Pickering/Scarborough area would also be included;

- since the GO Rail system would serve primarily travel from the Regions to Metro and it was expected that the volume of these trips would not increase as much under this concept, full service would be concentrated in the existing urbanized areas and not extended as far into the outer suburbs. All-day, two-way service would be provided on the existing lines on the Milton line (to Meadowvale), the Georgetown line (to Brampton), the Richmond Hill line (to Richmond Hill only and not to the planned extension to the Bloomington sideroad) and the Stouffville line (to Markham). As for Concept 1, not all trains on the Milton, Georgetown and Richmond Hill lines would serve Union Station; some services would be diverted to the North Toronto Subdivision to connect with the Spadina and Yonge subway lines in midtown Metro rather than proceeding downtown;

- a considerable increase in rapid transit service within Metropolitan Toronto and adjacent areas was postulated including a full Eglinton rapid transit service from Don Mills to the west boundary of Mississauga, a second cross town line in the Finch/Sheppard corridor, new radial lines from the centre to the northeast and to the northwest utilizing railway corridors, extension of the Harbourfront LRT to the Kipling station on the Bloor subway, development of a link between Kipling station and the airport area, extension of the Bloor subway into Mississauga, and the development of a north-south rapid transit line in Mississauga.

Concept 3: Nodal

As described previously, Concept 3 is expected to be between Concepts 1 and 2 in terms of growth in transportation demand but to have a more structured and compact urban form that would encourage use of public transit and enable it to operate more efficiently. The transportation network developed to test Concept 3 therefore included the following major elements:

- in the major road network, completion of Highways 403 and Highway 407 (to North Pickering). New additions to the freeway network would include a connection between Highways 407 and 401 in the Scarborough/Pickering area and a short section of a new east-west freeway located between Richmond Hill and Aurora; Black Creek Drive would be extended south to Lake Shore Boulevard as in Concept 1;

- a GO commuter rail service concept similar to that for Concept 1 with full service being extended on most of the lines and with new services being developed in the northwest and northeast quadrants;

- the rapid transit system would include the projects announced by the Minister together with a new peripheral route linking York and Peel in the Highway 407 corridor (conceived as a busway) and a new north-south route in Peel linking Brampton and Mississauga. The Bloor subway would be extended west into Mississauga to link with the new north-south rapid transit route. The Yonge subway would be extended north to Richmond Hill and the Spadina subway would be extended northwest to the 407 busway.

3. ANALYSIS OF CONCEPTS

In order to test the transportation concepts developed for each of the urban structure concepts as described in the previous section of this report, a computerized model of transportation demand was developed and applied. Based upon the results of this demand analysis the various transportation facilities were sized and/or modified and the resulting levels of service to the user and the capital and operating costs estimated. The transportation demand analyses were carried out for a typical weekday a.m. peak period (6:00 - 9:00 a.m.) in 2021 for each of the three concepts and transit and road traffic assignments were made to the respective networks for the a.m. peak period.

3.1 DEVELOPMENT OF TRANSPORTATION MODEL

A comprehensive and systematic method was needed to quantify transportation demand and level of service. It was decided that an existing computer based model framework would be the most reliable and flexible method for making these estimates.

The Ministry of Transportation, Metropolitan Toronto and the Regional Municipalities have been supporting a major effort, coordinated through the Data Management Group (DMG) at the University of Toronto, to provide information for transportation planning. The main results of this cooperative effort between the provincial government and the regional governments has been to:

- conduct, analyze and summarize a survey of transportation behaviour in the GTA (including Hamilton-Wentworth). The survey was conducted in 1986 with comprehensive results becoming available in 1989. This is referred to as the Transportation Tomorrow Survey (TTS);
- provide hardware and software facilities for transportation modelling using the EMME/2 computer package;
- develop coded networks for the 1986 road and transit systems.

To date the Data Management Group has used the EMME/2 package to examine current trip making behaviour in the GTA and to make extrapolations of travel demand. A fully calibrated transportation model to predict future demand has not been developed for the GTA. For this study therefore a number of methodological decisions had to be made.

Trip Generation

In the last two decades there has been a considerable increase in per capita trip making, both during the peak period and all day. This has been due to a number of factors:

- higher labour force participation rates as more women enter the out-of-home labour force;
- a decreasing proportion of children in the population, increasing the proportion of adults per household and the number of daily trips per household and per capita;
- greater personal wealth and car ownership, further increasing the propensity to travel.

Extrapolating these trends in the future is complicated by the expectation that all three of these effects have, to a considerable extent, run their course. We therefore made the simplifying assumption that per capita and per worker trip rates would not change materially over the analysis period.

Modal Split

A calibrated method for estimating travellers' propensity to use public transit rather than private auto is not yet available in the EMME/2 package for the Toronto area. It was therefore necessary to develop a modal split estimating method for this project. The question then became whether to estimate modal split on a trip end basis, that is at the origins and destinations, or on a trip interchange basis, that is for trips going from certain areas to certain other areas. Developing modal split analyses on a trip interchange basis requires a comparison of travel times by auto and by public transit. This in turn implies that a detailed coding and fine tuning of the road and transit networks be done which was beyond the scope of this study.

It was found that a very good relationship between density and modal split at the trip ends could be derived for 1986 based on the TTS data. In this case, density is operating as a surrogate for the level of public transit service that can be provided. In high density areas better transit service is available and more people use it. This should be a stable relationship that can be applied in the future. Because of this and because a trip end modal split could reflect the expected higher modal split associated with the structured, nodal development in Concept 3, it was decided to use this approach.

Two modal split formulations, linear and exponential, were tested. The linear formulation for origin and destination modal splits resulted in the following equations:

1. $mo_i = 0.0487 + 0.00585 * POPDENS_i + 0.00166 * EMPDENS_i$

2. $md_i = 0.0177 + 0.00414 * POPDENS_i + 0.00272 * EMPDENS_i$

Where: mo_i = modal split of trip origins from zone i
md_i = modal split of trip destinations to zone i
$POPDENS_i$ = population density of zone i (persons/ha)
$EMPDENS_i$ = employment density of zone i (jobs/ha)

This formulation assumes a linear relationship between propensity to use transit and urban density. The coefficients of determination (R^2) for equations 1 and 2 were 0.879 and 0.863, respectively for the 1986 application.

The exponential formulation examined was as follows:

3. $mo_i = 1 - \exp(-0.74546\ POPDENS_i - 0.26862 EMPDENS_i - 0.04215)$

4. $md_i = 1 - \exp(-0.45201\ POPDENS_i - 0.47007 EMPDENS_i - 0.01128)$

This formulation assumes a "logit" or "S-curve" relationship between transit use and density. The R^2 values for these equations for 1986 were 0.906 and 0.881 respectively, indicating that the "logit" or "S-curve" formulation fits the surveyed travel behaviour more closely than does the linear formulation.

It was therefore decided to use the logit formulation since, besides providing a slightly better fit to the 1986 data, it also produces more reasonable results for high density conditions; as population density and employment density increase the transit modal share increases but does not increase to a value greater than 100% of the trips departing from or arriving at a traffic analysis zone which is possible with the linear formulation.

Trip Distribution

Two methods of trip distribution were investigated, a "gravity model" which would estimate the distribution of trips based upon travel time between origin and destination, and a methodology which would extrapolate the 1986 trip patterns to the future adjusting for changes in the number of trip origins and destinations in each zone (the "Fratar" method). Both methods were tested. Two formulations of the gravity model were examined, one based upon impedance factors developed from the 1986 TTS data and one based upon an exponential function of interzonal travel times. Both tended to over emphasize inter-regional trips, for 1986 validation runs and, in our

judgment, in future analyses. The second method, the Fratar extrapolation of 1986 trips modified to reflect the new totals of land uses, was therefore adopted as providing more reasonable results. The algorithm used for the Fratar expansion included a "seeding" of the origin-destination matrices in those areas where the 1986 trips were sparse but where considerable growth was expected by 2021; the seeding was based upon travel patterns in the area surrounding the specific zones as well as 2021 travel times between zones.

Because the trip ends were separated by modal split at the origin and destination, a separate distribution analysis was applied for public transit and automobile trips. Using the Fratar method, this means that the 1986 orientation of the transit trips were used as a seed for the analysis of the likely orientation of the 2021 transit trips and similarly the 1986 auto trips for the automobile trips.

Assignment Methodology

The EMME/2 package includes an "equilibrium assignment" method which distributes traffic uniformly on roads according to their travel times and capacities, based upon an analysis of the likely impacts of congestion on travel times. This is a very attractive feature but, given the limitation on the time available for this project and the requirement to develop and code a realistic network of arterial roads as well as major highways, the "capacity restrained" assignment of trips to the road network was not used. An "all or nothing" assignment methodology was used, assuming that 1986 travel speeds will occur on existing roads and similar speeds on new facilities. This means that an equivalent level of service applies to all three concepts; however, in interpreting the results, adjustments had to be made in the analysis in that some roads tended to be overloaded and other roads tended to be underloaded.

Essentially the approach adopted was to estimate the demand and then to estimate the additional road capacity that would be needed to carry the estimated automotive traffic levels in 2021 at 1986 travel speeds. Similarly transit demand was estimated with bus and rail speeds similar to 1986 for each technology and the required service frequencies, equipment needs and capital and operating costs were estimated accordingly.

3.2 APPLICATION OF MODEL

The model was then applied to the three urban structure concepts for the year 2021. Exhibit 15 compares the resulting total travel demand with the actual travel demand in 1986 as measured by the TTS. The exhibit also shows the expected increase in trip making over 1986 in percentage terms. It can be seen that expected growth is quite comparable to that estimated by the very simplified gravity

EXHIBIT 15

PEAK PERIOD TRIPS FOR EACH CONCEPT

(Thousands of person-trips 6:00 a.m. to 9:00 a.m.)

	1986 TTS	2021 Concept 1	2021 Concept 2	2021 Concept 3
Trips within Metro	897	939 (5%)	1,524 (70%)	1,076 (20%)
Trips to Metro from Regions	240	492 (105%)	298 (24%)	417 (74%)
Trips from Metro to Regions	121	205 (69%)	246 (103%)	233 (93%)
Trips within Regions	405	1,067 (163%)	696 (72%)	998 (146%)
Trips between Regions	52	149 (187%)	88 (69%)	128 (146%)
	1,715	2,852 (66%)	2,852 (66%)	2,852 (66%)

Legend: xxxx = Thousands of person trips
(x%) = Percent growth from 1986

model as described in Section 2 of this report. Travel within Metro increases considerably in Concept 2 and very little in Concept 1. At the same time trips to Metro from the outlying regions increase most for Concept 1. Because of the greater population and employment within the regions in Concept 1, trips within the regions and between the regions also increase most for Concept 1.

Exhibit 16 shows the result of applying the trip end modal split equations and the trip distribution methodology described previously to the year 2021 land uses for the three urban structure concepts. As before, these are compared to the 1986 actual travel behaviour as measured by TTS.

The estimated increases in the transit share are associated with increases in population and employment density as the methodology used does not explicitly take into account changes in the level of transit service. There is an indirect relationship, however, in that increases in density permit more intensive transit services to be provided and, as outlined earlier, the conceptual transportation networks included more transit facilities and services in areas of high density under each urban structure concept. The method therefore produces estimates of increasing transit usage on most linkages for which transit accessibility is improved. Greater increases in public transit usage could be postulated based upon an expectation of the potential impacts of road congestion. It was decided, however, that these estimates of modal split would be used as they are based upon consistent and verifiable assumptions.

The estimated peak hour modal splits are slightly higher than the numbers shown on Exhibit 16 as the peak hour as a percentage of the three hour peak period is higher for public transit than for the automobile mode, being estimated to be approximately 50% for public transit as opposed to a peaking factor of 40% for the auto mode.

Transit Trips

Exhibit 17 shows the estimated a.m. peak hour transit trips for 1986 and for the three future land use concepts. These estimates do not include school bus trips or trips provided by specialized vehicles for the handicapped. Significant differences in the number of transit trips can be seen between the concepts as would be expected. With Concept 2 transit trips within Metropolitan Toronto increase by 139%.

Exhibit 18 provides a summary of the transit trip aspects of the three concepts, showing the proportion of trips destined to the Central

EXHIBIT 16

EXISTING AND FUTURE MODAL SPLIT LEVELS

(a.m. peak period proportion of total journeys on public transit)

		2021		
	1986 TTS	Concept 1	Concept 2	Concept 3
Trips within Metro	0.38	0.41	0.53	0.44
Trips to Metro from Regions	0.21	0.36	0.30	0.33
Trips from Metro to Regions	0.09	0.18	0.08	0.13
Trips within Regions	0.06	0.13	0.10	0.16
Trips between Regions	0.02	0.05	0.03	0.05
	0.25	0.26	0.35	0.29

EXHIBIT 17

A.M. PEAK HOUR TRANSIT TRIPS

(Person Trips in Thousands)

		2021		
	1986	**Concept 1**	**Concept 2**	**Concept 3**
Trips within Metro	170	192 (13%)	404 (138%)	234 (38%)
Trips to Metro from Regions	25	80 (226%)	44 (78%)	68 (178%)
Trips from Metro to Regions	5	18 (252%)	18 (144%)	24 (366%)
Trips within Regions	12	71 (485%)	34 (184%)	79 (550%)
Trips between Regions	0.4	3 (857%)	1 (220%)	3 (705%)
	212	366 (72%)	501 (136%)	409 (93%)

Legend: xxxx = Thousands of person trips
(x%) = Percent growth from 1986

EXHIBIT 18

ORIENTATION OF TRANSIT TRIPS

(A.M. Peak Hour Person Trips in Thousands)

	1986 TTS	2021 Concept 1	2021 Concept 2	2021 Concept 3
To Planning District 1	97	146 (51%)	210 (116%)	151 (56%)
To Rest of Metro	98	127 (30%)	238 (148%)	151 (54%)
To Regions	18	93 (417%)	53 (194%)	106 (489%)
TOTAL	212	366 (73%)	501 (136%)	409 (93%)

Legend xxx = Thousands of Person Trips
(x%) = Percent growth from 1986

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Area of Toronto, basically equivalent to Planning District 1. For all three concepts the proportion of total transit trips destined to the Central Area of Toronto is expected to decrease from the 1986 value although the absolute numbers will increase. For Concept 2, which has a considerable amount of development within Metropolitan Toronto, the proportion of transit trips destined to areas elsewhere in Metro is expected to increase considerably.

Auto Trips

Exhibit 19 provides a depiction of the automobile vehicle trips for the peak hour similar to that given for transit trips on Exhibit 17; however, Exhibit 19 gives the number of vehicle (automobile) trips rather than the number of person trips. The differences among the three concepts are quite significant, particularly for trips within the regions and among the regions. It can also be seen by comparison with Exhibit 17 that there is a considerable difference between the distribution of the transit trips and the automobile trips. The transit trips are much more centrally oriented and much more concentrated within Metro than are the road trips.

Exhibit 20 provides information on the assignment of the auto trips to specific routes. Automobile trips crossing the various screen lines (shown on Exhibit 21) around and within Metro are summarized and compared with the 1986 base. For Concept 2 the number of automobiles destined to the Central Area it is expected to decrease from the base to 2021 whereas for Concept 1 it is expected to increase by 35%; however, for all three concepts automobile trips across the Metro boundary cordon are expected to increase with an increase of 131% expected for Concept 1, 33% for Concept 2 and 87% for Concept 3. Exhibit 22 shows the comparison between the 1986 assignment and 1987 actual cordon counts; it can be seen that the fit is quite good for most of the screenlines. The 1986 simulated base is the actual 1986 trips as recorded in the TTS using the EMME/2 program to assign the surveyed trips to the road network.

Exhibit 23 shows the expected growth in automobile kilometres on the roads within each of the Regions from 1986 to 2021 under each of the three concepts as well as the percentage increases.

Level of Service

The road and transit networks were coded with speeds either identical or similar to those achieved in 1986. In other words, the potential impact of congestion was not taken into account in coding up the networks and in doing the assignments to the road network. On this basis, the expected average travel times are shown on Exhibit 24. It can be seen that the average travel times and trip lengths are expected to decrease in Concept 2 because of the proximity of many

EXHIBIT 19

A.M. PEAK HOUR AUTO TRIPS

(Thousands of Vehicle Trips)

		2021		
	1986	**Concept 1**	**Concept 2**	**Concept 3**
Trips within Metro	222	223 (0%)	286 (29%)	243 (9%)
Trips to Metro from Regions	76	114 (50%)	84 (11%)	112 (47%)
Trips from Metro to Regions	44	69 (57%)	85 (93%)	74 (68%)
Trips within Regions	152	369 (143%)	251 (65%)	336 (121%)
Trips between Regions	20	56 (180%)	34 (70%)	49 (145%)
	516	848 (64%)	741 (44%)	814 (58%)

Legend: xxxx = Thousands of vehicle trips
(x%) = Percent growth from 1986

EXHIBIT 20

SIMULATED AUTO VOLUMES ACROSS SCREENLINES
(A.M. Peak Hour Volumes)

Cordon	Scrln. (1)	1986 Base (Simulated)			2021 Concept 1		2021 Concept 2		2021 Concept 3	
		Volume (cars/hr)	Capacity (cars/hr)	V/C	Volume (cars/hr)	Ratio to base	Volume (cars/hr)	Ratio to base	Volume (cars/hr)	Ratio to base
Central Area (inbound)	West	14068	23660	0.595	30952	2.20	12590	0.89	25992	1.85
	North	6524	11375	0.574	7359	1.13	5192	0.80	5924	0.91
	East	17554	25970	0.676	13308	0.76	14531	0.83	15353	0.87
	Total	38146	61005	0.625	51619	1.35	32313	0.85	47269	1.24
Central Area (outbound)	West	10271	23660	0.434	5215	0.51	7966	0.78	6529	0.64
	North	2015	11375	0.177	2812	1.40	3799	1.89	2928	1.45
	East	5445	25970	0.210	5456	1.00	4394	0.81	6061	1.11
	Total	17731	61005	0.291	13483	0.76	16159	0.91	15518	0.88
Suburban (inbound)	West	18716	23280	0.804	20101	1.07	15037	0.80	19371	1.03
	North	37287	46808	0.797	63642	1.71	45278	1.21	51988	1.39
	East	15046	14101	1.067	10283	0.68	16933	1.13	16489	1.10
	Total	71049	84189	0.844	94026	1.32	77248	1.09	87848	1.24
Suburban (outbound)	West	10751	23354	0.460	12108	1.13	17745	1.65	13851	1.29
	North	27687	49599	0.558	33614	1.21	40128	1.45	35232	1.27
	East	3936	14102	0.279	4918	1.25	4924	1.25	4470	1.14
	Total	42374	87055	0.487	50640	1.20	62797	1.48	53553	1.26
Metro Bdy (inbound)	West	35360	43848	0.806	39142	1.11	28168	0.80	35439	1.00
	North	29287	45945	0.637	98025	3.35	55202	1.88	79547	2.72
	East	8133	7000	1.162	31088	3.82	13539	1.66	20862	2.57
	Total	72780	96793	0.752	168255	2.31	96909	1.33	135848	1.87
Metro Bdy (outbound)	West	22173	48185	0.460	35843	1.62	36937	1.67	34699	1.56
	North	19093	50226	0.380	59803	3.13	49665	2.60	52853	2.77
	East	3332	6401	0.521	3270	0.98	7950	2.39	5327	1.60
	Total	44598	104812	0.426	98916	2.22	94552	2.12	92879	2.08
North Scar.	East	7781	18698	0.416	9443	1.21	12038	1.55	10109	1.30
	West	13757	18702	0.736	27132	1.97	23656	1.72	19393	1.41
Hwy. 401 East	South	12946	18140	0.714	12037	0.93	12861	0.99	13893	1.07
	North	7358	15344	0.480	10789	1.47	18107	2.46	12617	1.71
North Humber	East	15710	17400	0.903	16625	1.06	13581	0.86	15392	0.98
	West	14312	17398	0.823	20645	1.44	25066	1.75	21391	1.49
Hwy. 401 West	South	704	2905	0.242	1022	1.45	1159	1.65	1040	1.48
	North	1794	2901	0.618	1702	0.95	2079	1.16	1694	0.94

(1) Screenlines are defined in Exhibit 21

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EXHIBIT 21

SCREENLINE NUMBERING SYSTEM

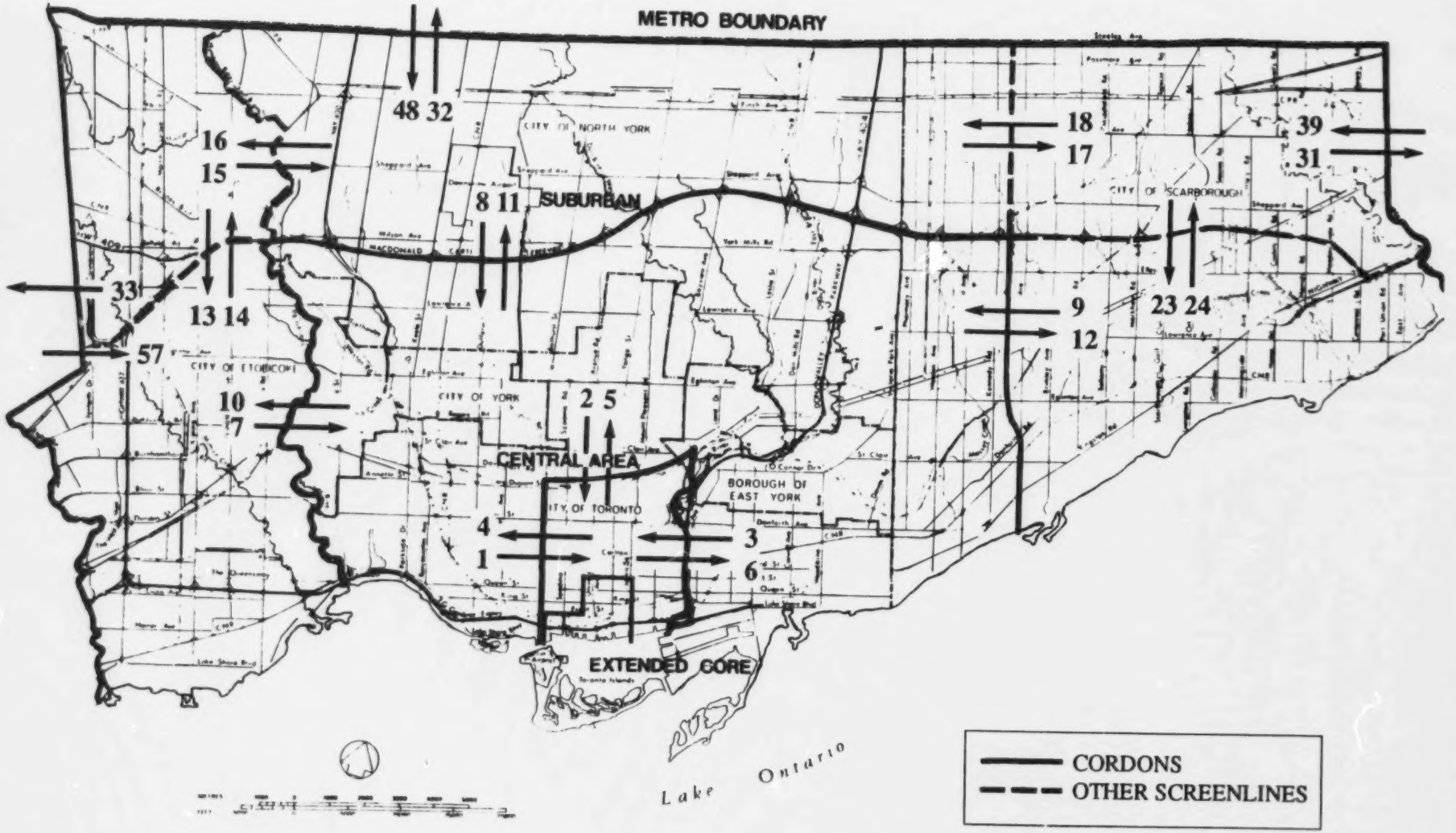

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EXHIBIT 22

AUTO VOLUME COMPARISON AT SCREENLINES
1986 SIMULATED VS 1987 OBSERVED
(A.M. Peak Hour Volumes)

Cordon	Screenline (1)	1986 (Simulated)			1987 Metro Cordon Count (2)	
		Volume (cars/hr)	Capacity (cars/hr)	V/C	Volume (cars/hr)	Ratio to base
Central Area (inbound)	West	14068	23660	0.595	14648	1.04
	North	6524	11375	0.574	7895	1.21
	East	17554	25970	0.676	16628	0.95
	Total	38146	61005	0.625	39171	1.03
Central Area (outbound)	West	10271	23660	0.434	7448	0.73
	North	2015	11375	0.177	3319	1.65
	East	5445	25970	0.210	7309	1.34
	Total	17731	61005	0.291	18076	1.02
Suburban (inbound)	West	18716	23280	0.804	16862	0.90
	North	37287	46808	0.797	38421	1.03
	East	15046	14101	1.067	10884	0.72
	Total	71049	84189	0.844	66167	0.93
Suburban (outbound)	West	10751	23354	0.460	11074	1.03
	North	27687	49599	0.558	32476	1.17
	East	3936	14102	0.279	4420	1.12
	Total	42374	87055	0.487	47970	1.13
Metro Bdy (inbound)	West	35360	43848	0.806	34427	0.97
	North	29287	45945	0.637	29687	1.01
	East	8133	7000	1.162	8109	1.00
	Total	72780	96793	0.752	72223	0.99
Metro Bdy (outbound)	West	22173	48185	0.460	24470	1.10
	North	19093	50226	0.380	21339	1.12
	East	3332	6401	0.521	4084	1.23
	Total	44598	104812	0.426	49893	1.12

(1) Screenlines are defined in Exhibit 21

(2) 1986 for the Central Area

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EXHIBIT 23

PEAK HOUR AUTOMOBILE-KILOMETRES BY GTA CONCEPT

(Thousands of Auto-km in the A.M. Peak Hour)

Regional Municipality	1986 Base (auto-km)	2021 Concept 1 (auto-km)	2021 Concept 1 (% Growth from 1986)	2021 Concept 2 (auto-km)	2021 Concept 2 (% Growth from 1986)	2021 Concept 3 (auto-km)	2021 Concept 3 (% Growth from 1986)
Metro	3,178	4,265	(34%)	4,094	(29%)	4,066	(28%)
Durham	527	1,356	(157%)	975	(85%)	1,146	(117%)
York	838	2,597	(209%)	1,555	(86%)	2,078	(148%)
Peel	1,062	2,170	(104%)	1,594	(50%)	2,039	(92%)
Halton	486	768	(58%)	547	(13%)	728	(50%)
TOTAL	6,091	11,150	(83%)	8,766	(44%)	10,056	(65%)

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EXHIBIT 24

AVERAGE TRIP CHARACTERISTICS

(a.m. peak hour)

Travel Time (Minutes)	1986	2021 Concept 1	2021 Concept 2	2021 Concept 3
Transit*	40.7	43.5	31.9	38.8
Road	21.9	20.6	19.8	20.3
Overall Average	27.4	27.5	24.7	26.5
Trip Length (km)				
Transit*	12.3	15.2	11.8	14.2
Road	13.8	14.9	13.9	14.4
Overall Average	13.4	15.0	13.2	14.4
Average Speed (km/hr)				
Transit*	17.4	19.3	21.3	20.4
Road	37.8	43.4	42.1	42.6
Overall Average	29.1	32.1	31.3	31.9

* Includes walk and wait time of trip.

activities to one another in the central part of the GTA. This is true for both public transit and auto trips.

In estimating the costs for these concepts, we have assumed that sufficient road and transit facilities would be supplied to maintain these average travel speeds as they were in 1986.

Summary of Travel Demand Estimates

The methodology developed for estimating future travel demand has assumed a stability of trip making habits. This is a reasonable assumption but it must be realized that, over a period of 35 years (from 1986 to 2021) there could be large changes in lifestyle.

The distribution of trips is based upon the pattern of population and employment. The lower average trip lengths and screenline volumes associated with Concept 2 occur, to a considerable extent, because of the balance between population and employment in the regions. Hybrid urban structure concepts could be developed which would decrease somewhat the travel flows in Concepts 1 and 3. As shown on Exhibit 1 in these two concepts there is more imbalance between population and employment with a greater concentration in jobs within Metropolitan Toronto. Concept 3 is intermediate with respect to this factor. It should be realized, however, that there are limits to the balance which would be feasible given the substantial suburban population growth in Concepts 1 and 3; greater balance is possible in Concept 2 because of its larger population in Metro.

3.3 CAPITAL COSTS

For each of the three concepts the public transit and road facilities were sized according to the demand estimates produced by the model. The capital costs of the various facilities proposed were then estimated. These are shown on Exhibit 25. The rapid transit facility costs are highest for Concept 2 whereas the road costs are highest for Concept 1.

The rolling stock capital costs shown are the increases in rolling stock required between 1990 and the year 2021. They do not include any amounts for replacement of rolling stock. Included in rolling stock are new subway cars, LRT vehicles, ICTS vehicles and buses. The GO Transit rolling stock is included in the GO Transit capital cost estimates.

On the road system the extensive freeway network in Concept 1 consumes a considerable amount of capital with lesser amounts in Concepts 3 and 2. The arterial network requirements in Concepts 1 and 3 are quite similar with a lesser amount required for Concept 2.

EXHIBIT 25

CAPITAL COSTS OF TRANSPORTATION NETWORKS

(millions of 1990 dollars)

	Concept 1	Concept 2	Concept 3
Public Transit			
- Rapid Transit Facilities	$4,607	$10,761	$8,478
- Rolling Stock	595	2,070	1,139
- GO Transit	1,962	1,583	1,962
TOTAL	$7,164	$14,414	$11,579
Roads			
- Major Roads and Freeways	8,920	4,782	5,793
- Arterial Roads	11,008	8,417	11,250
TOTAL	$19,928	$13,199	$17,043
GRAND TOTAL	$27,092	$27,613	$28,622

These estimated capital costs are the cumulative totals required between 1990 and 2021. They therefore include many elements that are already programmed or committed, including the $5 billion GTA transit improvement program announced on April 5, 1990 and the $1.2 billion GTA transit and road improvement program announced in the 1989 provincial budget.

Exhibits 26 displays the distribution of kilometres of new line and capital costs for the various rapid transit facilities. Exhibit 27 shows the distribution of lane-kilometres for the major roads and arterial roads among the regions. Exhibit 28 gives the comparison of major roads and arterial costs for the three concepts.

These capital cost estimates were developed by Lavalin Engineers Inc. They were necessarily based on a conceptual level of detail. Actual costs could vary considerably as the projects are designed. They do include a considerable contingency (25% for construction cost and 15% for land and vehicle acquisition) so that we believe, overall, they represent a reasonably conservative (that is adequately high) estimate of total costs. The costs include land purchases for the facilities where they are required.

3.4 OPERATING COSTS

Although estimates of operating costs were not required by the Terms of Reference for this project, they were expected to vary considerably between the various concepts because of the different modes of travel used. Therefore approximate annual operating cost estimates have been derived for transportation. These have been calculated on an annual basis for 2021. Exhibit 29 shows the estimated operating costs for all modes of transport under each of the concepts in 2021 as well as in 1986 on the same basis. Exhibit 29 also includes the operating costs for school busing and handicapped transportation which were estimated as described later in this section.

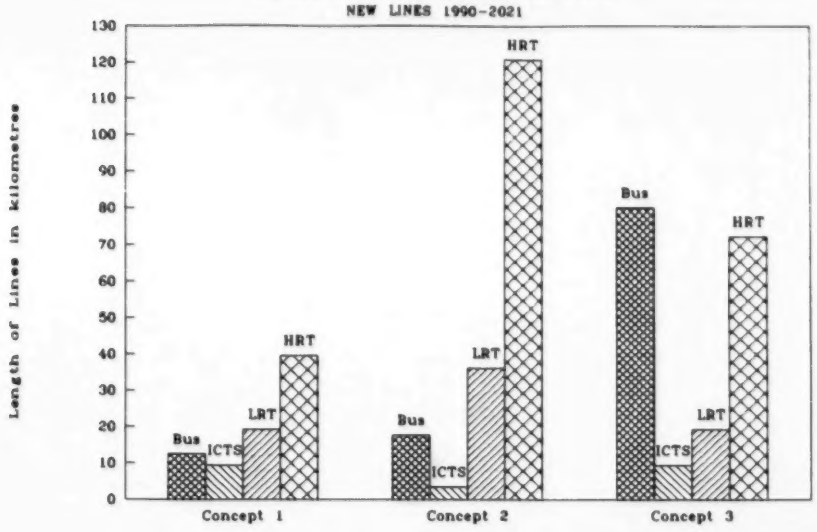
Public Transit

The public transit costs are estimated based upon current unit costs. They have been estimated based upon the ratio of peak hour operating hours to annual operating hours and using an estimated cost per vehicle hour for each type of public transit. There are relatively small differences among the concepts as rapid transit operating costs are lower than conventional surface transit on a passenger or passenger-kilometre basis.

EXHIBIT 26
NEW TRANSIT LINES

TRANSIT LINE LENGTHS

NEW LINES 1990-2021



TRANSIT CAPITAL COSTS

1990-2021, (Without Rolling Stock)

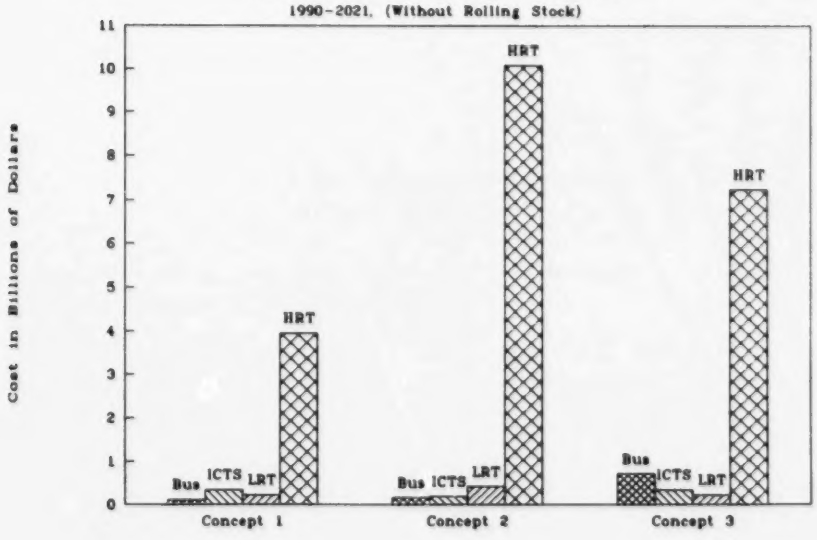


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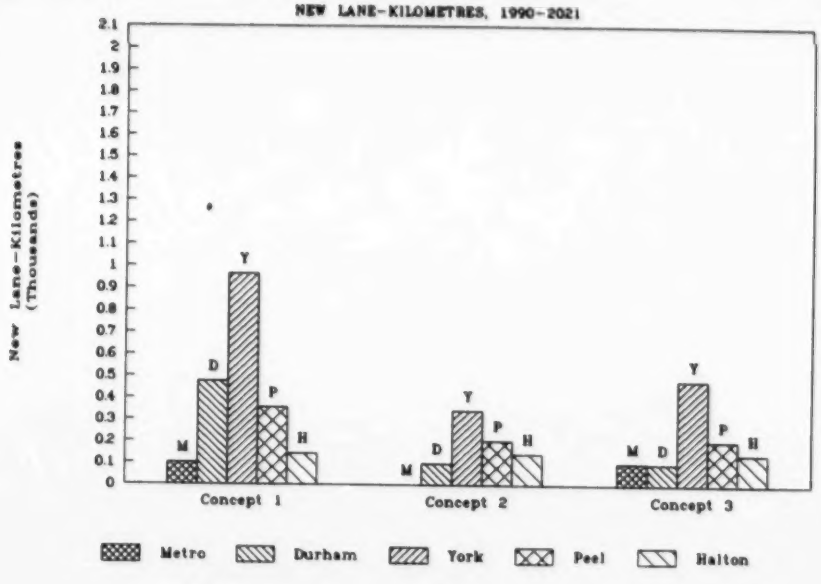
EXHIBIT 27
NEW ROADS

MAJOR ROADS



ARTERIAL ROADS

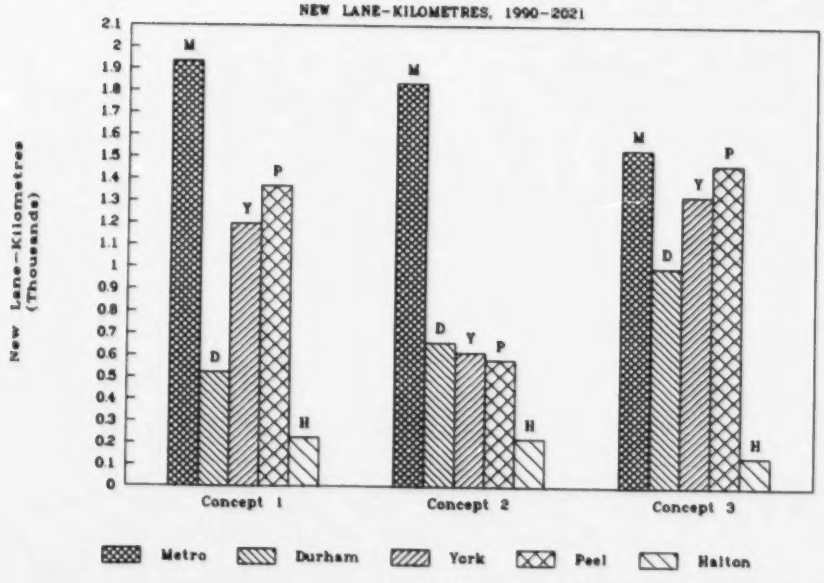


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EXHIBIT 28
ROAD INVESTMENT

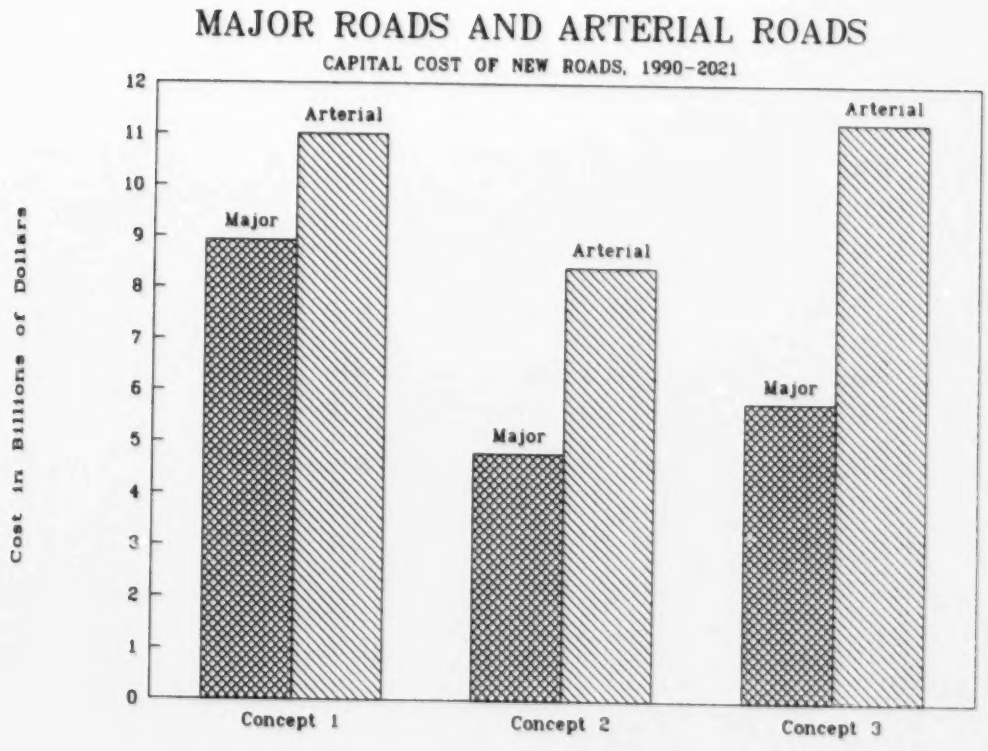

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EXHIBIT 29

TOTAL ANNUAL OPERATING COSTS

(millions of 1990 dollars)

	1986	2021 Concept 1	2021 Concept 2	2021 Concept 3
Public Transit	$ 697	$1,127	$1,371	$1,319
Road - Operations	159	239	211	231
- User	5,543	10,147	7,977	9,151
School Bus	150	267	171	218
Handicapped Transit	21	171	136	165
TOTAL	$6,570	$11,951	$9,866	$11,084

Roads

Road operating cost estimates are based upon average levels of cost per lane-kilometre for operating roads, including maintenance and repairs. They include costs for all freeways, arterials and major collectors but not local roads whose prime function is property access.

The road user costs are the total annual vehicle operating and ownership costs. This was estimated by multiplying the expected annual vehicle-kilometres by $0.25 per vehicle-kilometre. This methodology makes the following assumptions:

- that total annual vehicle kilometres vary directly with peak hour vehicle kilometres;
- that car operating costs vary with vehicle kilometres;
- that total car ownership cost varies directly with usage.

The road user costs represent costs that are borne by private citizens and are not governmental costs. Fuel taxes have been eliminated from the road user costs as to eliminate double counting with the governmental expenditures on roads.

School Busing

The number of trips made by secondary and elementary school children on buses or vans will vary to some extent depending on the urban structure. Currently, transportation to school is provided to students on large school buses or smaller vans or by subsidizing public transit trips. There are also a number of school trips made in the Metropolitan Toronto area on public transit that are not subsidized by the school boards. There is also funding for vans which carry disabled students to school. The Board of Education in the Greater Toronto Area funds school busing not only for home to school trips but also for field trips, home for lunch trips and swimming classes, etc. This analysis covers only home to school trips which are provided on school buses or vans. It is assumed that any students travelling to school by transit are included in the public transit numbers.

A telephone survey of Transportation Departments of Boards of Education in the Greater Toronto Area has confirmed that there is a larger proportion of students bused in the regions outside of Metro than in Metro Toronto. This survey shows that the percentage of students bused to school range from about 29% to 46% of total enrolment. These numbers include a small proportion of students using public transit. In Metropolitan Toronto the Public School Boards transport between 5% and 8% of pupils by school bus. The

Separate School Board numbers are higher due to the smaller number of schools operated; for the Metro Toronto Separate School Board the percentage of enrolment bused is 33% including those using public transit.

Data from the 1986 TTS survey rates are used to estimate the current and future school busing statistics under the different scenarios. The 1986 survey results indicate that the average number of trips for all purposes per capita per day is 2.16 and of this 8.7% are trips to school (703,000 daily school trips). In the Greater Toronto Area 33% of these 703,000 trips, or 231,000 trips, in 1986 were made on a school bus. Since each student makes 2 one-way trips per day, this translates into 116,000 students who used school bus transportation in 1986.

Using this information and the results of the telephone survey an estimate of the percent bused inside of Metro and outside of Metro was prepared as shown on Exhibit 30. This exhibit shows population within Metro and outside Metro for 1986 and for the three 2021 urban structure concepts. It also shows the resulting number of school trips, the estimate of the percentage of pupils bused in the two areas and the resulting number of school bus person trips.

It was estimated that in 1986 the total percentage of pupil trips made on buses was 16% in Metro and 57% outside of Metro. This gives a total percent bused in 1986 of 33% which agrees with the 1986 TTS statistics. These numbers are slightly higher than the survey of school bus boards; however in the last four years the total percentage of school children bused to school may have decreased due to increasing population densities and the construction of more schools.

Under urban structure Concept 1 (Spread), the percentage of children bused within Metro Toronto is assumed to stay approximately the same since the population will only increase marginally and very few new schools will be built to reduce the requirements for busing. Outside of Metro the population is expected to more than double from the 1986 population, which would mean that there would be some increase in density and the construction of new schools. The overall development pattern is expected to be low density and therefore the proportion of children transported by school bus would decrease only slightly. We have estimated that this would reduce to 50%. Therefore the total number of school bus trips required would be 411,000 which would mean that 36% of students would be bused as compared to 33% in 1986.

Urban structure Concept 2 (Central) assumes that Metro Toronto would become more compact with the population increasing by 73% between 1986 and 2021 while the population outside Metro would increase by 42%. Under this scenario the requirements for school busing in Metro Toronto would decrease significantly due to the increase in density while the requirements for school busing outside Metro would only decrease slightly as the development pattern would be similar to the current situation and the population would only increase slowly. Under this concept school busing requirements are expected to be 263,000 trips per day, with only 23% of all students requiring school busing.

In the third urban structure concept (Nodal), the population of Metro Toronto would increase slightly. The population outside of Metro would double; it would tend to increase in a nodal fashion so that schools would be constructed in these nodes which would reduce the requirement for school busing. It is assumed to reduce down to 45%. In this concept 335,000 school trips would be made each day by school bus, 30% of all school trips.

In summary, under the Spread concept, busing would increase slightly over the 1986 scenario while under the Central concept busing would decrease by 10% relative to the 1986 situation. Finally under the Nodal concept busing would decrease slightly, mainly due to a reduction in busing outside of Metro.

The cost of busing was also discussed within the telephone survey; it varies depending on whether the transportation is provided by a large school bus or by van. The large school buses cost approximately $700 per year per student while van operation ranges from $2,000 to $2,500 per student per year. Approximately two thirds of children use school buses and one third use a van. The cost of transporting a student to school is approximately $1,300 per year or about $7 per day given 186 school days per year. Exhibit 30 shows the resulting total cost under the various scenarios in constant 1990 dollars. Annual costs for busing students to school under Concept 1 is $267 million, under Concept 2 it is $171 million, and under Concept 3 $218 million.

Handicapped Transportation

The Ministry of Transportation of Ontario subsidizes municipalities to provide transportation for the disabled. The current eligibility criteria provide that anyone who cannot use the public transit service is eligible for special transit services. These are door-to-door services using special transit vehicles like the ORION 2, smaller vans and

EXHIBIT 30

ESTIMATE OF SCHOOL BUS ANNUAL CAPITAL AND OPERATING COSTS IN THE GTA - 2021

CONCEPT		POPULATION (000)	DAILY SCHOOL TRIPS (000)	PERCENT ON BUS	DAILY BUS TRIPS (000)	NO. OF STUDENTS ON BUSES (000)	TOTAL ANNUAL COST* (000)
1986	Metro	2,200	413	16%	66	33	
	Outside Metro	1,540	289	57%	165	82	
		3,740	703	33%	231	116	$150,218
1. SPREAD	Metro	2,428	456	16%	73	37	
	Outside Metro	3,592	675	50%	338	169	
		6,020	1,131	36%	411	205	$266,830
2. CENTRAL	Metro	3,800	714	5%	36	18	
	Outside Metro	2,200	413	55%	227	114	
		6,000	1,128	23%	263	132	$171,007
3. NODAL	Metro	2,800	526	12%	63	32	
	Outside Metro	3,220	605	45%	272	136	
		6,020	1,131	30%	335	168	$218,034

* Assumes an Annual Busing Cost per student of $1300.

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station wagons. The eligibility criteria have recently been expanded to allow elderly and others who have difficulty getting to a transit stop to use the specialized transit services. There is also a plan to make a limited number of rapid transit stations in Metro Toronto accessible to the disabled. With only some stations available this opens the service up to only a portion of the disabled who want to travel between the accessible stations.

A factor that will affect the demand for specialized transportation services in the future will be the larger proportion of the total population that will be elderly and, since the elderly are more prone to physical disabilities, the total disabled population will increase over the period of this study. In a study prepared for the Ministry of Transportation in March 1988 (Transportation for Disabled Persons in Ontario: Towards a Strategy for the 1990's), this aging factor is expected to be offset to some extent by advances in medical technology which will actually reduce the number of disabled persons.

The total population of the Greater Toronto Area can be split into a number of groups defining their ability to use public transit. The first group are the ambulatory who can use public transit with little or no difficulty and therefore are assumed to be completely able. The next group are those who are able to use public transit with some difficulty. These people are currently not eligible for specialized transit and must cope with the current public transit system. The last group are those who require door-to-door service due to problems with accessing the public transit system, getting to and from the public transit system or the actual use of the public transit system. There is a fourth group that is included in the disabled population which do not make any trips and are considered to be homebound. This latter group is not included in the analysis.

Given that the Ministry's expanded eligibility criteria include elderly who cannot walk to public transit, the number of disabled trips per capita was estimated using information from an August 1988 IBI Group report for the Metropolitan Toronto Treasury Department on the establishment of cost and performance indicators for Wheel-Trans service. At that time the base ridership had a rate of trips per capita of 0.36 and under expanded eligibility of 0.52 trips per capita. A mature level of service under the existing eligibility criteria would result in a trip rate of 0.6 annual trips per capita. Assuming the same increase between the existing Wheel-Trans and the mature Wheel-Trans trips per capita for the expanded eligibility, it is estimated that under expanded eligibility trips per capita will be 0.86. Therefore by the year 2021 the number of trips by the disabled

would be 5,177,000 per year assuming the expanded eligibility guidelines.

In the same study for the Metropolitan Toronto Treasury Department the average cost per trip in Metro was estimated to be $27.84 with the expanded eligibility criteria. Increasing this by the Consumer Price Index the cost per trip would be $30.60 in 1990 dollars. This cost per trip was used as the basis for estimating the costs of transporting disabled persons in 2021 for the three concepts. Although the cost per trip in the areas of the GTA outside Metro is currently less than within Metro it is assumed that in 30 years the services outside of Metro would grow to have characteristics similar to those of the current Wheel-Trans service and therefore would have similar costs.

The base cost per trip of $30.60 is factored by the ratio of the average trip length for each concept and the average trip length in 1986 for the disabled. Therefore for the Spread concept the base cost of $30.60 is increased by the ratio of 14.9km/13.8km to give a cost per trip of $33.04. A similar approach is taken for Concept 3. In Concept 2 (Central) it is assumed that there will be some effort made to improve the accessibility of the public transit system to the disabled population. Therefore the cost of carrying the disabled should decrease since they will be able to use public transit for part of their trip. In this analysis it was assumed that this will reduce their cost per trip by 15%. The 15% reduction is applied after factoring the cost by the ratio of trip lengths. Therefore, as Exhibit 31 shows, the total cost of providing transportation for the disabled is estimated to be $171 million for the Spread concept, $136 million for the Central concept and $165 million for the Nodal concept.

Total Operating Costs

Exhibit 29 also shows total annual transportation operating costs. It can be seen that these vary considerably among the three concepts with a difference of more than $2 billion per year between Concept 2 and Concept 1. The majority of these costs are the automobile user costs which are privately borne while the other costs on the table are all public costs.

3.5 OTHER COSTS

The main focus of this report has been on urban transportation costs. There are other transportation costs that will be incurred in the development of the Greater Toronto Area. These are discussed below.

EXHIBIT 31

ESTIMATE OF ANNUAL CAPITAL AND OPERATING COSTS FOR TRIPS BY THE DISABLED IN THE GTA - 2021

	2021 POPULATION (000)	DISABLED TRIPS PER CAPITA	TRIPS BY THE DISABLED (000)	AVERAGE TRIP LENGTH (km)	COST/ TRIP* ($)	TOTAL COST ($000)
1986	3,740	0.18	673	13.8	30.60	$20,600
1. SPREAD	6,020	0.86	5,177	14.9	33.04	$171,050
2. CENTRAL**	6,020	0.86	5,177	13.9	26.20	$135,635
3. NODAL	6,020	0.86	5,177	14.4	31.93	$165,310

* The cost per trip for the 3 concepts is calculated based on the 1986 cost per trip then factored by the ratio of the concept average trip length and the base average trip length.

** The cost per trip is reduced 15% to account for an increased use of public transit by the disabled

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Air Travel

At present commercial air services in the GTA are concentrated at Lester B. Pearson International Airport (LBPIA) with some additional services operating out of Buttonville, Toronto Island and Oshawa Airports. These satellite airports do not have the runway length to accommodate large jets. Thus, although they can supplement the capacity of LBPIA, they cannot replace it for major destinations.

The capacity limit at LBPIA for the present level of runway facilities has been reached. Capacity restriction are now in effect. There is a proposal which is now being studied for the construction of two additional runways at LBPIA. Even with these runways and significant improvements in operating methods and equipment, this will increase the capacity at LBPIA from the current "cap" of 70 movements per hour to perhaps 105 movements per hour. While this is a potential 50% increase, it cannot be expected to be able to cope with the anticipated increases in demand over the next 30 years. During this period at the least a second major airport will likely be required.

The federal government has purchased land in North Pickering to construct such an airport although, at the present time, there is no official commitment to do so. The capital cost of such a new facility obviously depends upon the amount of the activity that is displaced from LBPIA. By way of comparison, a major new airport in Denver is estimated to cost $7 billion, including land purchase. This cost presumably will be the responsibility of the federal government.

Provincial and municipal agencies would be responsible for access to the airport. In the road networks postulated for the concepts there is a freeway connection to North Pickering provided and, in two of the concepts, a rail service at peak times of the day. Thus we believe the costs shown include the ground transportation requirements of a second airport and there would be little or no differential impact among the three concepts in terms of capital costs for airport access, beyond those estimated.

Trucking

Trucks represent a considerable proportion of the total traffic flow on major roads. On some roads they can be as high as 20% of the total traffic flow. In all the estimates of capacity requirements made in this report, an allowance has been made for the potential usage of road capacity by trucks.

The question to be addressed here is whether there is a differential impact between the three urban development concepts on trucking

costs and the cost to provide facilities for trucking. There are two offsetting trends:

- under the central option (Concept 2), local truck trips can be expected to be shorter in length;
- on the other hand, with more concentration of population, road congestion can be expected to be greater.

It is therefore difficult to estimate the overall differential impact of the three concepts on truck operating costs and capital costs and no further attempt was made to estimate differences relating specifically to truck movements.

Intercity Passenger Rail

With respect to possible improvements in intercity passenger rail, there is no reason to believe that there is a differentiation in cost among the three concepts. The higher population densities within Metro in Concept 2 would permit easier access to an intercity rail terminal and be more conducive to ridership than the other development concepts. Historically, the federal government has been responsible for intercity rail transportation although, in recent years, the provincial government has become interested as well. Currently an Ontario-Quebec Task Force is examining the potential for high speed passenger rail service in the Quebec-Windsor corridor. Current efforts toward implementing a high speed rail service have been concentrated on making it financially self-supporting.

Rail Freight

Over the next 30 years there will be improvements needed on the rail system to carry freight. Although it was not implicitly included in the analysis of GO Transit improvement options, there is also pressure to remove freight trains from the urban rail network to free up capacity for GO Train movements. One method of doing this would be to relocate the CP traffic from the Galt, Havelock and North Toronto Subdivisions to the CN Halton and York Subdivisions, the CN bypass around Toronto. This was costed out in 1987 as having a minimum cost of $565 million which, in current 1990 dollars, would be in the order $650 million.

Port Facilities

No estimate has been included in this report for the development of harbours and port facilities. There is no reason to believe that they would differ among the concepts.

Use of Other Costs

These other costs have not been included in the comparison of the three concepts as, in the main, they do not differ in magnitude among the urban structure concepts. However, expected differences among the concepts in the quality of intercity linkages have been included in the qualitative comparisons as described in the next section of this report.

4. COMPARISON OF CONCEPTS

The overall objective of this project is to compare the relative advantages and disadvantages of the three urban development concepts in order to provide a basis or context on which decisions can be made concerning desirable patterns of urban development in the Greater Toronto Area. This chapter discusses the comparisons among the concepts from a transportation point of view.

4.1 FACTORS AND MEASURES

Factors were developed to compare the concepts in a number of areas. In the transportation area two factors for comparison were defined:

- **Factor 3.1:** Choice of modes and service levels;
- **Factor 3.2:** Transportation efficiency and costs.

Since each of these factor areas is quite broad and not susceptible to specific measurement, a number of quantifiable measures were defined for each of these factors. With respect to Factor 3.1, choice of modes and service levels, the following measures were defined:

- high transit accessibility and service level;
- high road accessibility and service level;
- high effectiveness of intercity connections;
- high population accessibility to rural areas.

With respect to Factor 3.2, transportation efficiency and costs, the following measures were defined:

- low average travel times, distances and costs;
- high proportion of each region's work trips remaining in the region;
- high transit efficiency and cost recovery;
- reduced road traffic congestion growth;
- reduced requirements for school busing;
- better opportunity to provide transit for handicapped persons;

- low transportation capital cost;
- low transportation operating costs.

Using these factors and measures the three urban structure concepts have been compared. Exhibit 32 shows the comparative ratings in tabular form.

Factor 3.1: Choice of Modes and Service Levels

High Transit Accessibility and Service Level

A concept is given a **high** rating under this measure if it provides a high level of transit accessibility (through the number and location of rapid transit and commuter rail lines combined with efficient feeder/ distributor services) and if the population and employment densities are such that high frequencies of services can be justified. Concept 1, Spread, is given a **low** rating since the low suburban densities would impede effective provision of transit service and would make it uneconomical to provide frequent service in many of the suburban areas. Concept 2, Central, is given a **high** rating because the high densities throughout the central, built-up area would justify the provision of a high level of public transit service and the strong balance between people and jobs in each region would promote relatively shorter work trips which can be well served by public transit and walking access. Concept 3, Nodal, is given a **medium** rating because, while densities are not as high as in Concept 2 and trips are longer, on average, the nodal urban structure would be highly compatible with providing efficient and effective transit service and trips within the nodes would be relatively short. Exhibit 32 lists the estimated route-km of improved commuter rail, and new rapid transit lines in the conceptual transit network developed and analyzed for each of the three urban structure concepts. It can be seen that Concepts 1 and 3 have relatively more km of improved GO services (reflecting greater suburban development) while Concepts 2 and 3 have relatively more km of new rapid transit (reflecting greater reliance on transit). While not shown on the Exhibit, Concept 2 would have relatively more km of rail (as opposed to bus) rapid transit than Concept 3 and higher frequencies of service, to serve the higher population densities in central areas.

EXHIBIT 32
COMPARISON MEASURES TABLE FOR THE TRANSPORTATION FACTORS

CRITERIA & FACTORS	COMPARISON MEASURES	CONCEPT 1: SPREAD	CONCEPT 2: CENTRAL	CONCEPT 3: NODAL
3.1 Choice of modes and service levels	**High transit accessibility and service level.**	**Low:** Low concentration impedes effective provision of transit service. Fewer rapid transit facilities are constructed. Improved Commuter Rail: 410 km New Rapid Transit: 81 km	**High:** More intensive network of public transit services available. Improved Commuter Rail: 360 km New Rapid Transit: 178 km	**Medium:** Good range of public transit available within and between communities. Improved Commuter Rail: 410 km New Rapid Transit: 181 km
	High road accessibility and service level	**High:** Extensive network of freeways and arterials. Freeways: 2,035 lane-km Arterials: 5,237 lane-km	**Low:** Limited expansion of road system. Freeways: 784 lane-km Arterials: 3,908 lane-km	**Medium:** Intermediate expansion of existing road system. Freeways: 1,024 lane-km Arterials: 5,472 lane-km
	The urban form and transportation concept contributes to **high effectiveness of intercity connections and access to intercity terminals**	**Medium-High:** Airport(s) well served by Freeway system; other intercity connections less well served.	**Medium:** Terminals accessible by rapid transit but road congestion more likely.	**Medium:** Reasonable connections to terminals by roads and transit.
	High population accessibility to rural areas	**Medium-High**: More extensive road system better able to carry recreational traffic; relatively poor transit access	**Medium-Low:** Greater likelihood of road congestion under recreational peaks; possibly greater propensity per capita to visit rural areas because of higher urban population density. Better transit access.	**Medium:** Intermediate levels, between the other two concepts, of likely road congestion and travel propensity to rural areas. Transit access similar to that of Concept 2.
3.2 Transportation efficiency/costs	**Low average trip times, distances and costs** (in the a.m. peak hour)	**Low:** Longer trips, higher costs, more auto trips. Auto / Transit / Total Avg. time/trip (min): 20.6 / 48.5 / 27.5 Avg. distance/trip (km): 14.9 / 15.2 / 15.0 Avg. cost/trip ($): 3.73 / 1.41 / 3.15 Person-hours of travel (M): .243 / .142 / .385 Person-km of travel (M): 11.86 / 5.13 / 16.99	**High:** Shorter trips, lower costs. Auto / Transit / Total Avg. time/trip (min): 19.8 / 31.9 / 24.7 Avg. distance/trip (km): 13.9 / 11.8 / 13.2 Avg. cost/trip ($): 3.48 / 1.25 / 2.70 Person-hours of travel (M): .204 / .164 / .368 Person-km of travel (M): 8.77 / 5.66 / 14.42	**Medium:** Shorter trips within nodes. Auto / Transit / Total Avg. time/trip (min): 20.3 / 38.8 / 26.5 Avg. distance/trip (km): 14.4 / 14.2 / 14.3 Avg. cost/trip ($): 3.60 / 1.47 / 2.99 Person-hours of travel (M): .230 / .151 / .381 Person-km of travel (M): 10.74 / 5.37 / 16.11

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EXHIBIT 32 (CONT'D)
COMPARISON MEASURES TABLE FOR THE TRANSPORTATION FACTORS

CRITERIA & FACTORS	COMPARISON MEASURES	CONCEPT 1: SPREAD	CONCEPT 2: CENTRAL	CONCEPT 3: NODAL
3.2 Transportation efficiency/costs (CONT'D)	**High proportion of each Region's trips remain in the Region**	**Low:** Considerable cross commuting between regions. Intra-regional 70% 4 regions to Metro 17% Metro to 4 regions 7% Among 4 regions 5%	**High:** Many more trips entirely within each region. Intra-regional 78% 4 regions to Metro 10% Metro to 4 regions 9% Among 4 regions 3%	**Medium:** Nodal concentrations encourage local movements. Intra-regional 73% 4 regions to Metro 15% Metro to 4 regions 8% Among 4 regions 4%
	High transit efficiency and cost recovery	**Low:** Spread development difficult to serve by public transit.	**High:** Concentration of population and employment permits economic provision of public transit service.	**Medium:** Nodal concentration can be served but long distances between nodes increase transit costs.
	Reduced road traffic congestion growth	**Medium:** All three transportation concepts are sized and costed to provide the same level of service for road traffic (ie. travel speeds similar to those in 1986).	**Medium:** All three transportation concepts are sized and costed to provide the same level of service for road traffic (ie. travel speeds similar to those in 1986).	**Medium:** All three transportation concepts are sized and costed to provide the same level of service for road traffic (ie. travel speeds similar to those in 1986).
	Reduced requirements for school busing (in 2021, annual cost in billions of 1990 dollars)	**Low:** Extensive school busing required throughout low density suburbs. School bus operating costs: $0.27	**High:** Intensified population in central areas means many more students would be able to walk or take regular transit to school. School bus operating costs: $0.17	**Medium-High:** Many students would be able to walk or take transit to school within and between nodes. School bus operating costs: $0.22
	Better opportunity to provide transit for handicapped persons and lower operating costs (in 2021, annual cost in billions of 1990 dollars)	**Medium:** More roads for paratransit but less opportunity to make new transit facilities handicapped-accessible. Handicapped transit operating costs: $0.17	**High:** Shorter trips and more opportunity to make new transit facilities handicapped-accessible. Handicapped transit operating costs: $0.14	**Medium-High:** Intermediate trip lengths but good opportunities to make new transit facilities handicapped-accessible. Handicapped transit operating costs: $0.17
	Low transportation capital costs (billions of 1990 dollars)	**Medium:** Similar total capital cost: Roads: $ 19.93 Transit: $ 7.16 Total: $27.09	**Medium:** Similar total capital cost: Roads: $13.20 Transit: $14.41 Total: $27.61	**Medium:** Similar total capital cost: Roads: $17.04 Transit: $11.58 Total: $28.62
	Low transportation operating costs for roads and transit operations (billions of 1990 dollars)	**Low:** Highest operating cost: Roads: $0.24 Transit: 1.13 Road User: 10.15 Total: $11.52	**High:** Lowest operating cost: Roads: $0.21 Transit: 1.37 Road User: 7.98 Total: $9.56	**Medium:** Intermediate operating cost: Roads: $0.23 Transit: 1.32 Road User: 9.15 Total: $10.70

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High Road Accessibility and Service Level

A concept is given a **high** rating under this measure if it provides substantially improved networks of major highways and arterial roadways for passenger and goods movements. Concept 1, Spread, is given a **high** rating because it would require and provide an extensive network of freeways and arterials. Concept 2, Central, is given a **low** rating because it would a limited expansion of the road system. Concept 3, Nodal, is given a **medium** rating because it would involve an intermediate level of road system expansion. As shown, Concept 1 provides substantially more new freeways than Concept 2 and Concept 3 provides less, while Concepts 1 and 3 provides more arterial lane-km than Concept 2 does.

High Effectiveness of Intercity Connections

A concept is given a **high** rating under this measure if the urban form and transportation concept contributes to high effectiveness of intercity connections between residential and employment areas and major intercity terminals such as Pearson International Airport, Union Station and the intercity bus terminal, and if it provides relatively good road connections for those wishing to enter or leave the metropolitan area by automobile. Concept 1, Spread, is given a **medium-high** rating because the major airports and road access to and from the GTA would be well served by the freeway system and the other intercity connections would be somewhat less well served because of the lower transit accessibility. Concept 2, Central, is given a **medium** rating because, while all intercity terminals would be more accessible by public transit, the less extensive road network would be more susceptible to traffic congestion under conditions of peak recreational travel. Concept 3, Nodal, is also given a **medium** rating because, while it would provide better transit connections than would Concept 1, the road connections would not be as extensive.

High Population Accessibility to Rural Areas

A concept has a **high** rating under this measure if the transportation system and likely congestion levels are such that the urban population would have good accessibility to adjacent rural areas and recreational areas. Concept 1, Spread, is given a **medium-high** rating because it would have the most extensive road system, although the system would be subject to congestion pressures owing to the spread suburban development and there would be less transit to help provide access to rural areas. Concept 2, Central, is given a **medium-low** rating because, while there would be better access by transit, there would be a greater likelihood of road congestion under recreational peaks and there might be a greater propensity to visit rural areas because of the higher urban population density. Concept 3, Nodal, is given a **medium** rating because it would have almost as much suburban development as under Concept 1 with a less extensive road network, although the higher densities and greater use of transit

would help to relieve road congestion pressures and the urban population would have a greater choice of travel modes to reach rural and recreational areas beyond the urbanized area.

Factor 3.2: Transportation Efficiency and Costs

Low Average Trip Times, Distances and Costs

A concept has a **high** rating under these measures if it has low average travel times per trip, low average trip distance, and low average trip cost, as estimated for the a.m. peak hour in the travel simulations carried out under this study. Person-km and person-hours of travel in the a.m. peak hour are also shown, as additional measures of travel effort. As indicated by the estimated average trip times, distances and costs shown for each concept in Exhibit 32, Concept 1, Spread, exhibits more travel effort under all three of these measures and is therefore rated **low**; Concept 2, Central, is rated **high** because of the shorter and less time consuming and costly trips under this intensified urban structure; Concept 3, Nodal, is rated **medium** because it displays an intermediate level of travel effort in terms of these measures.

High Proportion of Each Region's Work Trips Remaining in the Region

A concept is rated **high** under this concept if a high proportion of the work trips generated by its residents remain within the region (i.e. have work places within the same region) rather than crossing a regional boundary to a more distant work place. Again, Exhibit 32 lists the percentage of total a.m. peak hour trips which are intra-regional (i.e. remain within the region of origin), the percentage which cross from one of the four suburban regions into Metro Toronto, the percentage which cross from Metro Toronto into one of the four regions, and the percentage which move from one of the four suburban regions to another, as estimated by the travel simulations conducted under this study. Based on these estimates, Concept 1, Spread, is given a **low** rating because there would be considerable cross-commuting between regions, adding to the person-km of demand which has to be accommodated by the transportation network. Conversely, Concept 2, Central, is given a **high** rating because a considerably lower proportion of a.m. peak hour trips would cross from the suburban regions into Metro Toronto, and a high proportion would remain within each region. Concept 3, Nodal, is given a **medium** rating because it would generate an intermediate proportion of intra-regional and inter-regional trips. It should be noted that, while the travel simulations did not deal exclusively with work trips, a very high proportion of trips within the a.m. peak hour

are to work destinations, which is why the simulated results are interpreted as applying primarily to work trips.

High Transit Efficiency and Cost Recovery

A concept is given a **high** rating under this measure if the density and distribution of population and employment are such that they can be served efficiently by transit, thereby achieving a high revenue/cost ratio for the transit services provided. Concept 1 is given a **low** rating because the spread, low density development in suburban areas is difficult to serve efficiently by public transit, such that service frequency, load factors and revenue/cost ratios tend to be low. Concept 2, Central, is given a **high** rating because the concentration of population and employment in central areas permits economic provision of a high level of public transit service which, in turn, attracts high ridership and achieves a higher revenue/cost ratio. Concept 3, Nodal, is given a **medium** rating because the nodal concentrations can be served very efficiently by transit but the relatively long distances between nodes are more costly to serve than for the shorter trips and services under Concept 2.

Reduced Road Traffic Congestion Growth

A concept is given a **high** rating under this measure if the combination of urban structure and its compatible transportation system are such that future rates of growth of road traffic congestion may be moderated. The traffic demand analyses carried out under this study were designed such that the three transportation networks analyzed (one for each urban structure concept) each assumed an equal level of service as measured by the average travel speeds on the road system. In simulating each network, this was achieved by assuming recently measured (1986) travel speeds on all road links. The new road links added in each network were assumed to have travel speeds compatible with the 1986 speeds on existing links, while new transit links were assumed to have travel speeds appropriate to the type of technology (e.g. commuter rail, rapid transit, surface transit) involved, with surface bus speeds reflecting average traffic speeds on the various road links. An "unconstrained" traffic assignment was then carried out and the road system was "sized" by estimating and then costing the number of additional lanes of freeways and arterial roads which would be required to serve the estimated automobile travel demand. Estimated transit volumes were used to "size" the transit links in terms of required technology, frequency of service and number of vehicles required.

This approach means that equal levels of road and transit service would be provided under each concept. Accordingly, all three concepts are given the same rating, **medium,** under this measure. The differences among them are defined by the differences in road

and transit capital costs required to achieve the equal level of service postulated for each concept, and this is picked up under another measure in the comparison (i.e. low capital costs).

Reduced Requirements for School Busing

A concept receives a **high** rating under this measure if the amount of school busing required is reduced. Estimated annual operating costs for school busing are shown in Exhibit 32. Concept 1, Spread, is given a **low** rating because of the extensive amount of school busing required throughout the low density suburban areas, as is now the case in existing residential areas in the suburban regions. Concept 2, Central, is given a **high** rating because the high population density in central areas means that more students would be able to walk to school or take regular transit, thereby allowing a substantial reduction in the effort and cost required for school busing. Concept 3, Nodal, is given a **medium-high** rating because many students would be able to walk or take transit to school within and between the relatively high density nodes postulated in this concept.

Better Opportunity to Provide Transit for Handicapped Persons

A concept is given a **high** rating under this measure if the combination of urban densities and transportation networks is such that transit services for handicapped persons can be provided relatively cost-effectively as new transit facilities are introduced. Concept 1, Spread, is given a **medium** rating because it would provide a more extensive road network for paratransit services serving handicapped persons but less opportunity to make new transit facilities handicapped-accessible. Concept 2, Central, is given a **high** rating because it would generated shorter trips (more efficiently served by paratransit) and would provide more opportunity to make new transit facilities handicapped-accessible. Concept 3, Nodal, is given a **medium-high** rating because it would generate intermediate trip length trips and would provide substantial opportunities to make new transit facilities handicapped-accessible.

Low Transportation Capital Costs

A concept has a **high** rating under this measure if the total estimated capital costs required to construct its conceptual transportation network between 1990 and 2021 are relatively low compared to the other concepts.

As shown, Concept 1, has an estimated transportation capital cost of $27.1 billion, while Concept 2 has an estimated cost of $27.6 billion and Concept 3, $28.6 billion. As also shown, while there are significant differences in the costs for transit and for roads among the three concepts, these tend to balance out so that the total capital costs are essentially the same within the conceptual estimating

accuracy of this study. Accordingly, all three concepts are given a **medium** rating under this measure.

Low Transportation Operating Costs for Roads and Transit Operators

Estimates were made of the annual operating cost experienced in 2021 by Public Works departments operating the road system (which vary with the number of lane-km in the network), by the transit operators (which vary with the number of revenue-hours and revenue-km of transit service provided with transit fare revenues netted out) and by travellers using the system (e.g. automobile operating and ownership costs during the a.m. peak period with taxes netted out). These estimates are shown for each concept, in terms of approximate annual operating costs, for each of the three concepts. The pattern is similar to that for road capital costs: owing to the high cost impact of its more extensive road system, Concept 1 has the highest operating costs, while Concept 1 has the lowest and Concept 3 has an intermediate level. Accordingly, Concept 1, Spread, is given a **low** rating under this measure, Concept 2, Central, is given a **high** rating, and Concept 3, Nodal, is given a **medium** rating.

4.3 OTHER CRITERIA

Transportation can have a major impact on some of the environmental factors. One measure defined in Background Report 7 is the potential impact of transportation on air pollution. Exhibit 33 shows the estimated air pollution impacts of each of the three scenarios as well as the 1986 base. These estimated emissions are based on empirical relationships between fuel consumption, emissions and average speed based on a methodology adapted from "Procedure for Estimating Highway User Costs and Fuel Consumption and Air Pollution," United States Federal Highway Administration, 1980. It does not assume any technological improvement to vehicles between 1986 and 2021. It therefore may over-estimate the potential emissions but the relative ranking between the three concepts should be indicative. Annual emissions can be estimated by multiplying the amounts in Exhibit 33 by a factor estimated to be 3,250. It can be seen that Concept 2 has significantly lower emissions compared with Concept 1. Concept 3 is intermediate.

Another measure defined for comparison of the concepts is transportation energy consumption. Differences similar to those estimated for vehicle emissions can be noted on Exhibit 33.

EXHIBIT 33
EMISSIONS AND ENERGY CONSUMPTION
(A.M. Peak Hour)

Scenario: 1986 Base

	Area/Mode	Vehicle Hrs	Vehicle Km	Avg Spd (km/h)	Energy Consumption (MJ)	Emissions			
						CO (Kg)	CO2 (Kg)	HC (Kg)	NOX (Kg)
A	Metro	85521	3177946	37	13170406	48950	883445	4204	3331
U	Durham	10692	527236	49	2022898	6204	135692	603	811
T	York	15502	838111	54	3177950	9125	213171	924	1449
O	Peel	30244	1062213	35	4495699	17314	301563	1452	1026
	Halton	7868	485553	62	1839079	4806	123362	513	989
	Total Auto	149828	6091059	41	24706033	86400	1657233	7696	7605
	Transit	2919	73449	25	1668016	1276	100658	179	788
	Total	152747	6164508	40	26374048	87676	1757891	7875	8393
	Per Capita	0.041	1.651	-	7.065	0.023	0.471	0.002	0.002

Concept 1: Spread

	Area/Mode	Vehicle Hrs	Vehicle Km	Avg Spd (km/h)	Energy Consumption (MJ)	Emissions			
						CO (Kg)	CO2 (Kg)	HC (Kg)	NOX (Kg)
A	Metro	103543	4264793	41	17083218	59351	1145909	5328	5162
U	Durham	22032	1356140	62	5135584	13444	344485	1434	2753
T	York	39944	2590932	65	9866453	24911	661823	2706	5606
O	Peel	47316	2170387	46	8448594	27267	566715	2568	3036
	Halton	12659	768218	61	2906671	7686	194974	815	1533
	Total Auto	225494	11150470	49	43440520	132659	2913906	12851	18089
	Transit	4453	172331	39	3242627	2073	163587	290	1280
	Total	229947	11322801	49	46683146	134731	3077493	13141	19369
	Change Since 1986	51%	84%	22%	77%	54%	75%	67%	131%
	Per Capita	0.038	1.881	-	7.755	0.022	0.511	0.002	0.003
	Change Since 1986	-7%	14%	-	10%	-5%	9%	3%	43%

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EXHIBIT 33 (CONTINUED)

Concept 2: Central

	Area/Mode	Vehicle Hrs	Vehicle Km	Avg Spd (km/h)	Energy Consumption (MJ)	Emissions			
						CO (Kg)	CO2 (Kg)	HC (Kg)	NOX (Kg)
A	Metro	99687	4094375	41	16414578	57136	1101058	5123	4936
U	Durham	16908	975250	58	3686408	10105	247277	1051	1828
T	York	25933	1554624	60	5879043	15680	394355	1656	3056
O	Peel	36779	1594485	43	6294459	21123	422220	1940	2069
	Halton	9181	547087	60	2068497	5540	138751	584	1067
	Total Auto	188487	8765821	47	34342984	109584	2303661	10353	12956
	Transit	5143	132470	26	2895901	1978	161948	273	1182
	Total	193630	8898291	46	37238885	111562	2465609	10626	14138
	Change Since 1986	27%	44%	14%	41%	27%	40%	35%	68%
	Per Capita	0.032	1.478	-	6.186	0.019	0.410	0.002	0.002
	Change Since 1986	-21%	-10%	-	-12%	-21%	-13%	-16%	4%

Concept 3: Nodal

	Area/Mode	Vehicle Hrs	Vehicle Km	Avg Spd (km/h)	Energy Consumption (MJ)	Emissions			
						CO (Kg)	CO2 (Kg)	HC (Kg)	NOX (Kg)
A	Metro	99827	4065691	41	16341613	57204	1096164	5110	4845
U	Durham	20402	1145529	56	4333248	12110	290666	1246	2076
T	York	33650	2077918	62	7870707	20559	527952	2195	4235
O	Peel	46525	2038898	44	8025859	26734	538359	2467	2684
	Halton	12150	727745	60	2751992	7344	184598	775	1429
	Total Auto	212554	10055781	47	39323418	123950	2637739	11793	15270
	Transit	4641	119305	26	2750828	2084	165892	291	1277
	Total	217195	10175086	47	42074246	126034	2803631	12083	16547
	Change Since 1986	42%	65%	16%	60%	44%	59%	53%	97%
	Per Capita	0.036	1.690	-	6.989	0.021	0.466	0.002	0.003
	Change Since 1986	-12%	2%	-	-1%	-11%	-1%	-5%	22%

Notes:

1. Energy consumption and emissions figures are rough approximations based on simplified relationships between emissions, energy consumption and average speed for a composite 1986 vehicle fleet. While the absolute figures are highly uncertain, the relative differences between the scenarios are reasonably accurate.

2. To isolate the effects of urban form alone on energy consumption and emissions, vehicle emission and consumption rates have been frozen at 1986 fleet levels. Actual emissions and consumption levels will probably be substantially lower in 2021, due to technological improvements in vehicle efficiency and emissions controls.

3. Sources of Information:
   - CW Dale. PROCEDURE FOR ESTIMATING HIGHWAY USER COSTS, FUEL CONSUMPTION AND AIR POLLUTION. FHWA, US Department of Transportation, March 1980 (revised April 1981).
   - Wilbur Smith and Associates. METROPOLITAN TORONTO AREA TRANSPORTATION ENERGY STUDY. Municipality of Metropolitan Toronto, Toronto Transit Commission, Ontario Ministry of Transportation and Communications, December 1980.
   - US Environmental Protection Agency. MOBILE SOURCE EMISSIONS FACTORS. Washington DC, 1978

APPENDIX A

PERSON-KILOMETRES OF TRAVEL

EXHIBIT A-1

PEAK HOUR TRANSIT PERSON-KILOMETRES IN THOUSANDS

		2021		
	1986	Concept 1	Concept 2	Concept 3
Trips within Metro	1,597	1,666 (4%)	3,657 (129%)	2,096 (31%)
Trips to Metro from Regions	727	2,476 (241%)	1,390 (91%)	2,113 (191%)
Trips from Metro to Regions	92	363 (295%)	363 (295%)	485 (427%)
Trips within Regions	73	535 (633%)	219 (200%)	590 (611%)
Trips between Regions	11	88 (700%)	29 (164%)	87 (691%)
	2,500	5,128 (105%)	5,658 (126%)	5,371 (115%)

Legend: xxxx = Thousands of person-km
(x%) = Percent growth from 1986

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EXHIBIT A-2

PEAK HOUR AUTO PERSON-KILOMETRES IN THOUSANDS

		2021		
	1986	Concept 1	Concept 2	Concept 3
Trips within Metro	1,916	1,907 (0%)	2,279 (19%)	2,072 (8%)
Trips to Metro from Regions	1,888	3,372 (79%)	1,769 (-6%)	2,706 (43%)
Trips from Metro to Regions	906	1,380 (51%)	1,661 (83%)	1,518 (68%)
Trips within Regions	1,261	3,515 (179%)	2,090 (66%)	2,995 (138%)
Trips between Regions	642	1,690 (163%)	970 (51%)	1,446 (125%)
	6,613	11,864 (79%)	8,768 (33%)	10,737 (62%)

Legend: xxxx = Thousands of person-km
(x%) = Percent growth from 1986

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